SUSTAINABLE AGRICULTURE IN CENTRAL ILLINOIS: VISIONING THE FUTURE

BY

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THESIS

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ABSTRACT

Agricultural regions are under increasing pressure to provide more food for increasing populations while global biodiversity is at risk imperiling the future health of people, wildlife and native species. Integration of the two promotes agricultural sustainability as well as provides vital ecosystem services that sustain human and wild species populations. This paper explores current research in biodiversity, ecosystem services, agricultural sustainability and landscape ecology and applies the information to a predominantly agricultural region in Central Illinois. This paper also examines the role landscape designers and planners can play in working with planning agencies and local communities to develop future scenarios to promote conservation of biodiversity and agricultural sustainability throughout the region. Through a series of vignettes, I have attempted to illustrate how native species can be incorporated into an agricultural region in Tazewell County, Illinois. Relating these vignettes to seasonal food web diagrams illustrates complex ecological relationships and the importance of plant species diversity to support biodiversity in space and time. Though much research exists regarding these topics there is little information specific to Illinois, and would be a valuable area for future research.

ACKNOWLEDGEMENTS

The successful completion of this thesis would not be possible without the continued support, patience and precious time of my adviser, Laura Lawson to whom I would like to extend a heartfelt thank-you. Please allow me to also thank my other committee members who have spent their time reviewing and supporting my endeavor. A last word of gratitude I must extend to my family and friends who have also been continually supportive and encouraging through this (rather long) process.

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PREFACE

Status quo: The state of things; the way things are, as opposed to the way they could be. (http://en.wiktionary.org/wiki/status_quo)

Central Illinois farmland is not often a place people want to *be* in. This is illustrated by the observation that rarely can you find anyone *there*. The landscape primarily serves as conduit for shuttling persons from home to school, work, the grocery store and back again. If indeed someone is in the landscape it would likely be the farmer in spring or fall, barricaded in an enormous tractor or combine either putting in or taking out the annual harvest that serves as a portion of his families' income for the year. Even the occasional farmstead looks deserted, one wonders if someone indeed lives there for it is as quiet and lifeless as the surrounding landscape. The rural home, surrounded by thousands of acres of corn and soybeans, is a refuge from the world surrounding it.

And why would people be there? There is little to be there for. There are no places for people. There is no place to walk, perhaps enough room to ride your bike if you feel up to contending with the (albeit occasional) 60-70 mile per hour traffic, and there is little to see that is different than what you can see from a glance through your window: acres and acres of agricultural fields. Occasionally there is a patch of woods that looks interesting and inviting, but it's privately owned, caught behind barb wire fencing and signs that read "Keep Out", "Private Property." A simple walk in "nature" requires one to get in the car and drive, often for 30 miles or more to find a publicly accessible piece of land.

Central Illinois and many other agricultural areas throughout the Midwest, the United States, and even other parts of the world came to be this way with the best of intentions.

Encouraged by scientists, government officials, and market economies, agricultural regions changed dramatically over the past 100 years in order to be more efficient, to grow more productive crops, and to provide food for a growing world. In the past 25-30 years, the repercussions of these actions have become more and more apparent and alarming. Eutrophication in the Gulf of Mexico, an increasing list of threatened, endangered and extinct species, decline of rural populations, soil erosion, and environmental contamination all can be attributed to the industrialization of agriculture.

As a former Central Illinois resident, I felt compelled by this topic and as a landscape designer was excited by the opportunity to turn my attention to the place that was once my home, and imagine other possibilities and futures for the dispersing communities, impoverished farmlands, and nearly barren ecosystems.

It perhaps is time for the status quo to change. Indeed it has to change in order to preserve and improve what life is left and bring life back to America's Heartland. "Life," referring to more than just people but plants, animals, communities and culture- referring to that something to be there *for,* that will bring people there and enable them to engage with the world around them.

CHAPTER 1: INTRODUCTION

The Midwestern landscape is dominated by agriculture. According to the United States Department of Agriculture, approximately 65% of land cover in the seven Midwestern states (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, and Wisconsin) is in row-crop agriculture. This percentage is higher in Illinois, Iowa and Indiana, which lack extensive forested areas present in the upper Midwest. In Illinois, 76% of the land statewide is under production with over 15 counties (11 of which are in Central Illinois) reporting over 90% of land in agriculture. In all but 5 counties (three encompassing Chicago and its metropolitan region and two in the Shawnee National Forest) within the state, agriculture accounts for a minimum of 50% of land use (http://www.isgs.uiuc.edu/nsdihome//webdocs/landcover/stats.html accessed online July 2010). In Illinois, less than 1% of the original landscape remains (Robertson 2001). Illinois is home to a reported 54,000 native species of plants, fungi, mollusks, fishes, amphibians, reptiles, birds and mammals (http://www.inhs.uiuc.edu/~kenr/corridors.html [7/25/2010]).

Agriculture is recognized as one of the greatest threats to biodiversity and global ecosystem dynamics (Smeding and Snoo 2003; Burel et al. 2004 Tscharntke et al. 2005; Bennett et al. 2006). Any plan to restore or conserve biodiversity must consider how it can be incorporated into managed landscapes instead of relying on nature preserves for conservation of biodiversity. This is especially relevant in the Midwest where the relative proportion of natural areas to managed landscapes is quite small and threats to native species conservation are significant. Biodiversity incorporated into productive landscapes also has the capacity to return vital ecosystem services to agricultural systems, enhancing sustainability and reducing negative impacts of agriculture.

Over the past thirty years, agriculture and its effects have become the focus of researchers, agriculturists, environmentalists, and government institutions (among others) in an effort to ensure continued agricultural productivity, environmental protection, conservation and restoration of native species, and to support vital rural communities. A primary focus of much recent research has been to evaluate the value of biodiversity in ecosystems. This research focus is due in part to the realization that loss of natural habitats and biodiversity worldwide has diminished local, regional, and global “ecosystem services,” a term describing the myriad of benefits to humans that result from diverse, healthy ecosystems. Examples of ecosystem services include provision of goods, flood and drought mitigation, purification of air and water, soil generation and soil fertility as well as aesthetic/cultural values.

Restoration of biodiversity needs to be addressed at both the individual farm plot scale and at the regional, landscape scale. Agrobiodiversity research provides many methods for integrating biodiversity on the plot scale. Ample and well-connected natural areas will tie these areas together in the landscape to create a vibrant biodiverse landscape matrix. As illustrated by the environmental degradation caused by farming and similar activities farms are a part of ecosystems- what happens on the farms has consequences in ecosystems both near and far.

What is emerging is a vision of landscapes not dominated by vast areas of corn and soybeans, but a hybridized agricultural landscape capable of being highly productive and at the same time existing in harmony with natural areas, native species and rural inhabitants.

In this paper, I will review current research and literature in sustainable agriculture, landscape ecology, biodiversity as well as examine the role that landscape designers and planners can take to help move the endeavor forward of implementing sustainable agricultural practices and restoring biodiversity. I have chosen the agricultural landscape of Central Illinois to be the focus of this paper, as I am most familiar with it and it is the landscape I envision this future for, though I believe that the majority of topics and ideas set forth in this paper are applicable to any agricultural region.

It is my purpose to illustrate the importance of a regional landscape perspective in the development of sustainable agricultural landscapes as well as show the importance of using native plants in restoring biodiversity and habitats throughout agricultural regions in order to connect to and support the health and vitality of remaining natural areas.

CHAPTER 2: SUSTAINABLE AGRICULTURE, BIODIVERSITY & ECOSYSTEM SERVICES

Sustainable agriculture and biodiversity are inherently linked. This link may seem obvious when considering that vast expanses of monoculture crops, urban areas, and other highly managed environments have replaced what was once natural and diverse. Natural environments are self-sustaining ecosystems that have the ability to provide nutrients, food, and other resource for the species within without depleting itself or its external environment. In contrast, agricultural systems require intense management and numerous external inputs essentially using multiple resources to provide one (be it food, fuel or fiber). Ecosystem functions (or services when ascribed a human benefit) are described as, “the minimum aggregated set of processes (including biochemical, biophysical and biological) that ensure the biological productivity, organizational integrity and perpetuation of the ecosystem” (Swift et al. 2006, 115). These functions are the foundation for life on this planet, one of the most important being the conversion of sunlight to energy by plants which forms the basis of the global food chain. Other examples of vital ecosystem functions are carbon sequestration, nutrient recycling, decomposition, and climate regulation. Many ecosystem functions are interdependent and happen at different scales simultaneously as ecosystems “aggregate” on regional and global scales.

Many ecosystem functions are of particular interest in agroecosystems (and would be considered ecosystem services) such as erosion control, water infiltration, soil building, nutrient regulation, pollination and pest control. Without a biodiverse ecosystem to provide these services, they must be imparted to the agroecosystem by the farmer or land manager. These interventions can cause as much damage to the environment as benefit to the crops resulting from nutrient leaching, soil erosion and chemical pollution. Additionally these measures are expensive and rely on an ever-decreasing supply of oil and other natural resources. The Millennium Ecosystem Assessment identified 24 key ecosystem services only 4 of which have been enhanced by human intervention (crops, livestock, aquaculture and carbon sequestration), while 15 have been degraded (MEA 2005, 5). The loss or compromise of diverse ecosystems resulting from human expansion and manipulation of the natural environment has disrupted the ecosystem services that not only benefit agriculture, but all of society (Jackson et al. 2007).

Historically in the United States agriculture has not been compatible with nature and can be viewed as a physical expression of human domination over nature. Fred Kirshenmann, director of the Leopold Center for Sustainable Agriculture believes this “domination of nature” is traceable to the Puritans who believed it was their “manifest destiny to tame the wilderness and build the Kingdom of God” (Kirschenmann and Gould 2006, 18). This Puritan ethic, he feels is deeply embedded in the American psyche and is likely a key factor in the environmental degradation and present land-use conflicts found throughout the United States. Agricultural expansion and intensification is one of the greatest current threats to biodiversity (Donald and Evans 2006).

Advocates of sustainable agriculture argue for the recognition that agriculture would be more sustainable if integrated and reconciled with the environment. To the same extent that natural areas have been conserved within the landscape the remaining areas have been managed with little, if any regard to environmental and wildlife impacts. For the health and productivity of both agriculture and wilderness, these two land uses must be reconnected to create farms that sustain wildlife and wildlife that sustain farms. Aldo Leopold puzzled over the disparity between [ecological] conservation and agriculture, and did not understand why the two were not more integrated. To Leopold, conservation is a state of harmony between men and land (all of the things on, over, or in the earth). “You cannot love game and hate predators; you cannot conserve the waters and waste the ranges; you cannot build the forest and mine the farm. The land is one organism” (Leopold 2006, 116).

Any agricultural system in order to be sustainable must consider the natural environment. As defined by United States government (U.S. Code Title 7, Section 3103):

> Sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will over the long term:
> - Satisfy human food and fiber needs
> - Enhance environmental quality and the natural resource base upon which the agricultural economy depends.
> - Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
> - Sustain the economic viability of farm operations.
> - Enhance the quality of life for farmers and society as a whole. (http://www.csrees.usda.gov/nea/ag_systems/in_focus/sustain_ag_if_legal.html [accessed 6/30/2010])

The definition clearly indicates that agricultural production is closely tied to the environment in which it is practiced, calling for agriculture to *enhance* the natural resources on which it *depends*.

It seems apparent that restoring and conserving biodiversity within and throughout agricultural regions would help restore ecosystem functions and services, creating sustainable agroecosystems that provide vital links in the landscape to native ecosystems and aid conservation of native or “wild” biodiversity. As agricultural practices have increasingly intensified over the past 100 years, native species have been relegated to ever decreasing and more widely dispersed natural landscapes. Connecting these patches through corridors and stepping stones enables species movement and re-colonization and also provides additional habitat and resources. These connections will become increasingly important with anticipated climate changes over the next several decades as native species will have to adjust to changing climactic conditions in order to survive. The ability to move and recolonize new habitats could help prevent or reduce massive species extinction predicted by many authorities as a result of global warming. In order for biodiversity to serve the dual function of providing ecosystem services as well as protect and conserve native species, it must incorporate native plants and habitats within and throughout the agricultural landscape. In natural ecosystems plants, wildlife and abiotic elements of the environment (e.g., climate, soil) co-evolve forming intricate relationships (source). Using native species in biodiversity restoration and schemes to provide ecosystem services can take advantage of these co-evolved relationships and also provide important habitat and resources to native species. A brief exploration of the concept of biodiversity will help explain these concepts.

The meaning of “biodiversity,” it has been noted, varies depending on who is defining it. Biodiversity to an agronomist generally refers to crop diversity, to an agroecologist it refers to crop, auxiliary species and habitat, and to the ecologist it refers to wild species diversity (Moonen and Barberi 2008). There are also a variety of approaches to restoration that align with these three viewpoints. An agronomist would take an “eco-engineered” approach (selecting particular species to construct ecosystems to perform specific functions), an agroecologist might choose an “explorative” approach (restoring different combinations of species, monitoring the results, and adapting the system to provide a best-fit between ecosystem and human well-being) and an ecologist would choose a “restorative” approach (restoring the biodiversity that was there prior to disturbance) (Naeem et al. 2009). All approaches have their merits but they also have their limitations and are often at odds with each other. But I suggest that a fourth approach that is founded on utilization of native plants in biodiversity restorations merges these often disparate views to create hybridized, regionally appropriate approach.

Simply put, diversity is a means of describing an ecosystem in terms of the different number of species present and the relative abundance of those species (Campbell and Reece 2005). But this simplistic definition does not go deep enough into the concept of biodiversity to be able to make reasonable conclusions on how it functions in order to know how to restore it nor does it indicate the importance of the type of biodiversity (be it native or other). To encourage meaningful dialogue and to set goals for biodiversity preservation and restoration, a common definition of biodiversity is needed that encapsulates the complexity and integrity inherent in a biodiverse, native ecosystem. The Convention of Biological Diversity, and outcome of a working group established by the United Nations, defines biodiversity as “the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems” (CBD 1992, 5). This definition begins to address the important connection between ecosystem function and biodiversity. Species within any ecosystem are not a random assemblage but a result of co-evolutionary processes between the biotic and abiotic components of the ecosystem (Swift et. al 2004). It is also important to consider that biodiversity and ecosystem complexity are not static but a response to disturbance, climactic variation and other factors that cause change over time. It is the diversity or complexity of the ecosystem that enables it to respond to these perturbations (Swift et al. 2004). A definition proposed at a Keystone Convention on Biodiversity captures this nuance by incorporating the word "processes" in its definition. "Biodiversity is the variety of life and its processes. It includes the variety of living organisms, the genetic differences among them, the community and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning, yet ever-changing and adapting" (Farnham 2007, 14). Hence, an ecosystem is a dynamic system that is inherently linked to its surroundings. The particular climatic conditions, soil conditions, wind, water, the species present at that particular point in time, and the interactions amongst all these elements within the landscape all contribute to an ecosystem's biodiversity – or according to the first definition, the number of species present and the relative abundance of those species. That native plants are important is underscored by this understanding of the complexity of ecosystems for these plants have evolved complex interactions with the native animals, insects, birds, etc. that rely on them for food, nectar, pollen, and shelter.

Ecosystem function (and provision of ecosystem services) is not a direct result of biodiversity, but result from the functions and relationships of the species therein. This can be confusing as biodiversity is typically described in terms of number of species and evenness (or the relative proportions of each species). These measurements lend no information regarding the types of interactions occurring in the ecosystem. Adding to the complexity is that numbers of species and evenness are highly variable over time and though this may lead to insights on the functions occurring within the ecosystem it is not possibly to qualitatively evaluate an ecosystem merely by counting the number of species within (Bengtsson 1998; Hooper et al. 2002; Swift et al. 2004).

As a result, the functional diversity (or simply what species do) of an ecosystem is often used as a means of evaluation as opposed to simple counting numbers of species. But focusing simply of functional diversity also leads to an incomplete understanding of biodiversity in ecosystems. For though it is not simply the quantity and variety of species present, nor is it simply the functions individual species provide – it is a combination of the two.

This can be illustrated by redundancy (the existence of multiple species preforming similar functions within an ecosystem) present within natural ecosystems. Researchers puzzled over the presence of redundancy and performed experiments showing that the redundancy of ecosystems can be greatly reduced without a corresponding loss in function (Bengtsson 1998; Swift et al 2004). However, further research indicated that this ability to continue functioning is limited to environmental stability. Redundancy becomes integral to maintenance of ecosystem function when perturbations occur for species seem to have preferred environmental conditions under which they perform best. When environmental conditions change ecosystem evenness changes as well as different species become the dominant providers of that function (Bengtsson 1998).

Functional diversity is often the sole consideration in agrobiodiversity schemes that aim to provide specific ecosystem services (such as the biological control of pest populations) often utilizing a handful of species known to provide that function (King 1993; Fiedler et al. 2008). In managed ecosystems environmental perturbations would require intervention (via the farmer of land manager) in order to continue to function (provide services) (Smeding and Snoo 2003).

This implies that for ecosystems to provide services, diversity is imperative as well as a management tactic that allows the ecosystem to respond to disturbances. This also indicates that connecting to existing natural ecosystems can help buffer both systems from potential perturbations. Both systems would benefit from gene and species flow across the landscape naturally providing much needed diversity. In fact, research indicates that diversity on a regional scale helps provide "resilience," to individual (ecosystems and agroecosystems) or the ability for the ecosystem to recover from or adapt to a changing environment in a manner which does not compromise ecosystem health (Jackson et al. 2007, Moonen and Barberi 2008).

Ecosystem services are a convenient way to conceptualize, categorize and value the ecosystem functions that directly benefit humans. It seems that in order to conserve and restore biodiversity, we have to find a reason (economics seems to be the best motivator) to justify doings so. Though this may be an effective strategy for helping society understand and embrace biodiversity as an integral part of everyday life (Wiens 2009) it does little for the preservation of native biodiversity as thus far it has eluded economic valuation.

Most often the preservation of native or wild biodiversity is argued for based on moral, aesthetic or cultural values (source). While these are important reasons to conserve native biodiversity it is the position of this paper that, on a fundamental level *native* is implicit in the definition of biodiversity. Referring to the Keystone definition, biodiversity is inherently linked to the community and ecosystem in which it occurs. By removing a species from its native environment and planting it in a non-native environment is a corruption of the concept of biodiversity and leads to biotic homogenization – the process of local species being replaced by non-native species leading to a global decrease in species biodiversity (Mckinney and Lockwood 1999; Olden et al. 2004; Olden and Rooney 2006).

This problem of biotic homogenization is especially acute in regards to plant species. Agricultural ecosystems worldwide (which account for approximately 30% of global land use) are planted with just 12 species of grain crops, 23 vegetable crops, and 35 fruit and nut varieties (Altieri 1999; Jackson et al. 2007). The plant component of ecosystems has been indicated to exert a powerful influence over the total ecosystem function due to it being the foundation of the food chain. Diversity of plant species has been shown to reduce incidence and severity of pest attacks, increase productivity and lend stability over time to the ecosystem (Swift et al. 2004). The reduction of plant species diversity on a local and global scale increases the likelihood of broad-scale pest outbreaks requiring intense, costly intervention to prevent major disruption to global food production.

In agrobiodiversity schemes it is common for farmers throughout the country rely on several known plant species that have shown to be effective in biological control of crop pests. Though these species are effective, researchers found that native species used in biological control were often more effective than the commonly used non-native species (Fiedler and Landis 2007). Native perennial species can provide overwintering sites for insects and wildlife important in pollination and pest control. As a result of co-evolution floral and nectar resource availability corresponds with emergence or migratory patterns of insects and birds and are available well before typically used non-native annual species that must be planted yearly. Diversity of species extends floral and nectar resources throughout the growing season helping to retain important predacious and pollinating species on site. Using native perennial plants in agrobiodiversity schemes can provide additional habitat, floral and nectar resources, and seed to native wildlife.

The potential to increase weed and pest frequency in crops is a common concern of using native species in agrobiodiversity schemes or in the presence of adjacent natural habitats, but this is not supported in the literature. In fact, natural areas with diverse plant species show a reduced susceptibility to weedy than do adjacent crop habitats (Dukes 2002; Fremark et al. 2002).

A comparison of natural ecosystems, sustainable agroecosystems, and conventional agroecosystems using parameters such as yield, resilience, and internal nutrient cycling indicated that the more similar to the local natural ecosystem the more sustainable the agroecosystem (Gliessman 2000).

Though of course non-native agricultural species as well as other landscape plants will remain important components of agricultural landscapes, biodiversity conservation must start locally and incorporate native plants in agrobiodiversity and throughout agricultural landscapes whenever possible. It has been suggested by several authors that biodiversity is an important aspect in sustainable agriculture, but must be addressed at two scales, the regional landscape scale as well as the individual plot scale. Agrobiodiversity strategies employed by individual farmers are site and production specific and should include native species when possible. Individual farms should be considered as a part of a regional landscape as networks of native habitats and corridors permeate the agricultural matrix. Research has indicated that biodiversity schemes on the individual farm scale can be more effective when encompassed in a less hostile (more biodiverse) agricultural matrix (Baum et al. 2004). The next chapter will develop the idea and illustrate the importance of a biodiverse landscape matrix.

CHAPTER 3: LANDSCAPE ECOLOGY

The science of landscape ecology is concerned with assemblages of individual ecosystems (patches) within a landscape and the flow of energy, materials, and organisms that create the overall landscape composition (the landscape matrix) (Campbell and Reece 2005; Dramand, Olson, and Forman 1996). Using concepts from landscape ecology can be an effective strategy for planning and designing landscapes at both the site and regional scale. The following chapter will discuss general principles of landscape ecology that will serve as the framework for the planning and design of sustainable agricultural landscapes as applied to Central Illinois in Chapter 5. Landscape ecology is a particularly useful strategy to address landscape planning

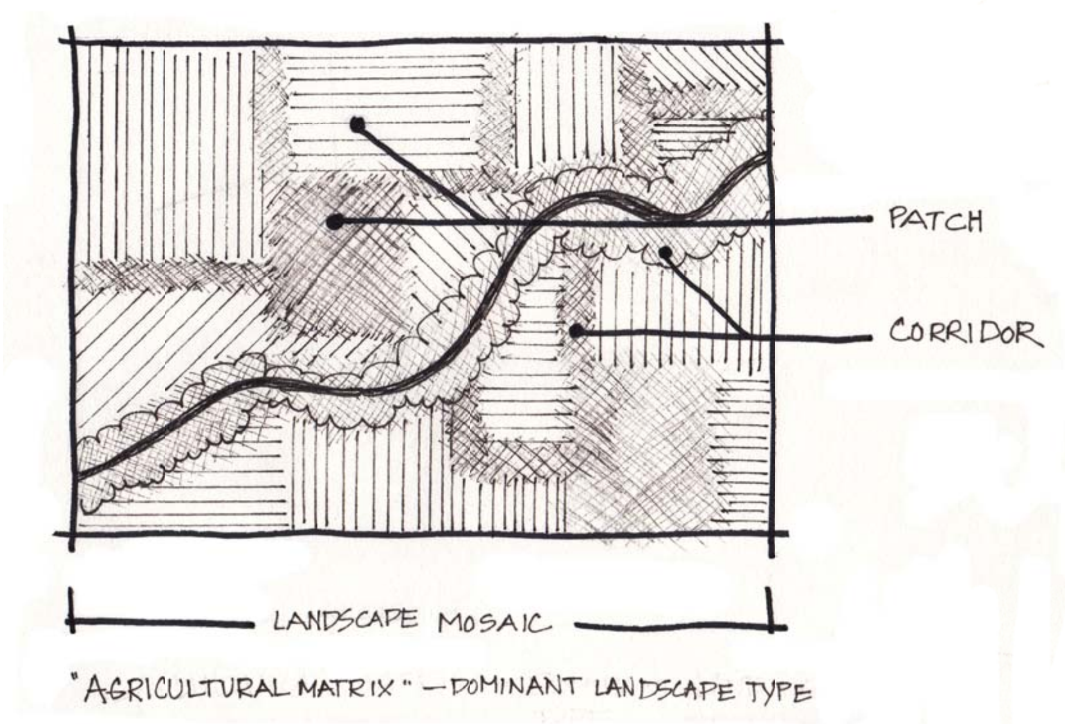

Figure 1. Components of the Landscape Mosaic (diagram by author).

and design as it considers all the components and activities (human, industry, wildlife, etc.) within a landscape from a broad perspective.

There are several key elements that compose a landscape as shown in Figure 1; these are the patch, the corridor, and the matrix. These elements taken as a whole are referred to as the landscape mosaic. Patches are non-linear elements of the landscape with a distinct character either due to vegetation or geo-morphology. Patches vary by size, shape, edge character and relate to other patches in the landscape based on quantity, degree of connectivity or isolation, and distance. The landscape matrix is the predominant landscape type in which patches are embedded. For example patches of woodland that exist within a region of agricultural would be in an agricultural matrix. Patches can be connected to other patches by corridors, or linear elements in the landscape that also have a distinct vegetative character from the matrix and are likely similar in character to the patches connected.

Patches that are relatively distant from each other in the landscape and not connected by corridors are considered to be fragmented. Fragmented patches are generally considered to be of poor habitat quality because the populations of species within lack the resources to sustain themselves and likely will go extinct. Patch quality also depends on patch size as larger patches will have more resources and are able to sustain more stable population sizes, though patch size and quality vary by species size, mobility and location in the food chain (larger, more vagile species require larger habitats and are often the most difficult populations to sustain effectively in fragmented patches).

Edge character of both patches and corridors is an important factor in the type of species supported. It has been found that within a patch more generalist, predaceous species inhabit edges of the habitat while more sensitive species (often of conservation value) tend to inhabit the center of the patch. A highly curvilinear edge will provide more edge habitat supporting greater numbers of predaceous species often to the detriment of the sensitive species. This may be in part due to the increase interaction that results from a more curvilinear edge as shown in Figures 2 and 3. This interaction can be either negative or positive depending on the qualities of both patch and matrix. As both edges are permeable there will always be interaction between the patch and the matrix- plants, organisms and abiotic elements (wind, water, and soil) will always move across this edge to some extent.

The structural complexity of the edge between patch and matrix also influences the interactions between the two. A more structurally complex edge can

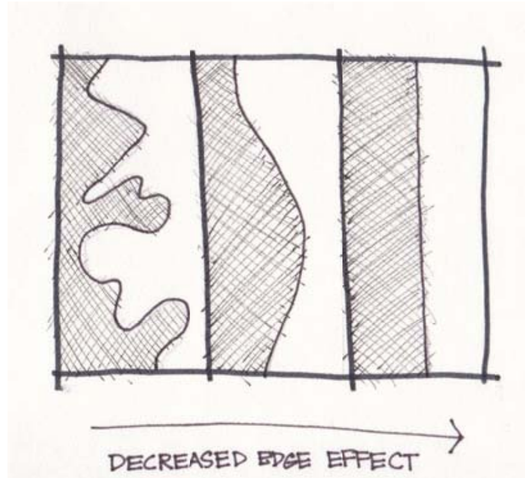

Figure 2. Edge Effects (diagram by author).

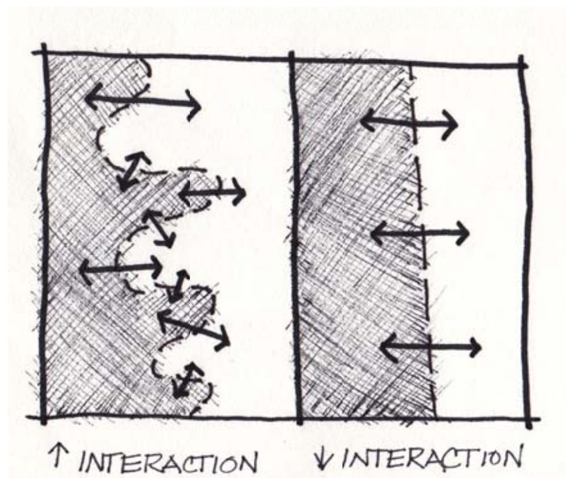

Figure 3. Patch/Margin Edge Interaction (diagram by author).

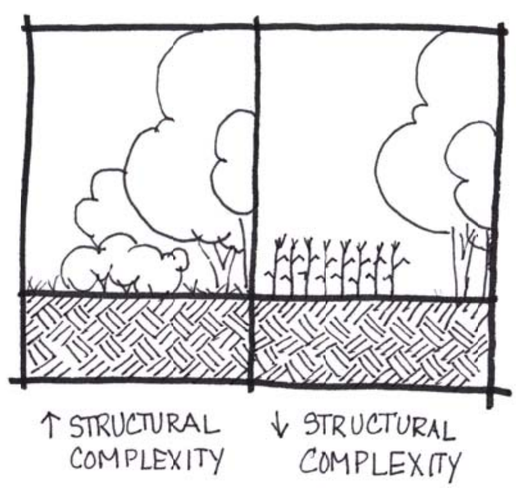

Figure 4. Structural Complexity (diagram by author).

serve as a buffer to the patch encouraging greater species diversity at edges of habitats potentially providing greater access to the matrix for pollinating and predaceous species (Figure 4). The varying edge effects have important ramifications for patch design and maintenance. Edge effects are diminished with increasing size of the patch and it has been found that edge effects are reduced beyond 150 feet into a patch. As such, a patch that is 300 feet wide would in effect have no interior habitat as the entire patch would experience edge effect (Barnes 2000). Hence, patches must reach a threshold size before being effective habitat for the conservation of sensitive species.

Historically, patches have been managed as islands of biodiversity within seas of inhospitable landscape (be it urban, agricultural or otherwise), a management style influenced by the concept of island biogeography. The concept of island biogeography has been around for possibly hundreds of years, with traces of the idea apparent in Charles Darwin's writings (MacArthur and Wilson 1967). The concept was solidified in the 1960s by biologists Richard MacArthur and Edward O. Wilson in their seminal book, *The Theory of Island Biogeography*. They developed this theory to explain variations in species richness in islands in Pacific archipelagoes, concluding that species populations will reach equilibrium over time based on island size and distance from the mainland (the source of colonizing species). The theory predicted that species in smaller and more distant islands would eventually go extinct due to limited resources within to maintain populations and reduced colonization rates (Forman 1995).

The island concept was very attractive because it simplified extensive ecosystems into discrete elements that were easier to conceptualize and study (MacArthur and Wilson 1967).

Conservation areas such as the United States' national parks were historically managed as patches within inhospitable landscapes with the improvement of the habitat patch being the focus of conservation efforts (Pickett 1978; Barnes 2000). As a result of the theory of island biogeography, it was realized from this theory that conservation areas needed to be of significant size and complexity to prevent populations from becoming extinct (Rosenberg et al. 1997). Additional cause for concern arose from increasing habitat fragmentation pushing existing patches farther and farther from each other, preventing the flow of species between habitats, potentially exacerbating species extinction within conservation areas.

Scientist and conservationists turned to corridors in an effort to connect isolated patches as a solution to the problem of habitat fragmentation and isolation. It was theorized that corridors could effectively bolster populations concentrated in patches to prevent local extinctions (Rosenberg et al. 1997). Inherent complexities in ecosystems have proven to be limiting to the effectiveness of corridors in encouraging species migration between patches. One of the biggest obstacles is designing corridors to support movement of different species. Certain factors- especially corridor width, have been found to greatly enhance the effectiveness of corridors (Clark and Reeder 2005). Species movement and distribution is affected by body size, life history traits, and mobility patterns (Burel et al. 2004). To relegate all species to movement through linear corridors may be detrimental to the survival of many. Research suggests that corridors can alter natural predator-prey interactions, often to the advantage of larger, more vagile species thus altering a "balance" otherwise achieved in an unaltered ecosystem (Tscharntke et al. 2004; Donald and Evans 2006).

Most recent research has shifted focus to the regional scale suggesting that improving the landscape matrix is the key to maintaining viable populations of diverse species within patches. Studies have indicated that by “softening” the matrix or making it more hospitable improves wildlife movement through corridors (Baum et al. 2004; Tscharntke et al. 2005; Donald and Evans 2006; Vandermeer and Perfecto 2007; Concepcion et al. 2008; Weins 2009; Dover and Settele 2009).

Patches and corridors remain vital elements in the landscape and should continue to serve as conservation elements within the broader landscape matrix. It is important for natural areas to be woven into the fabric of the landscape matrix in the form of patches and corridors to provide vital ecosystem services that may not be a part of an individual farmer’s production plan. Vital ecosystem services occur at the landscape scale that requires consideration at the regional scale (Concepcion et al. 2008; Kremen 2005, MEA 2005).

Incorporating environmentally-friendly agricultural practices is imperative to improving sustainability and biodiversity throughout the agricultural matrix. The science of agroecology provides a foundation and framework to incorporate sustainable practices into individual agroecosystems. Agroecology can be described as a process of discovery, exploration and research in agriculture through a focus on a comprehensive understanding of nature and its processes. Agroecology focuses on developing an understanding of the form, dynamics, and function of the relationships within the farm ecosystem (Gliessman 2000). This understanding enables environmental manipulation in order to enhance production while minimizing environmental and social impacts with fewer external inputs.

Miguel Altieri, professor of agroecology at the University of California at Berkeley, believes that the idea behind agroecology is “to develop agroecosystems with minimal dependence on high agrochemical inputs, emphasizing complex agricultural systems in which ecological interactions and synergisms between biological components provide the mechanisms for the systems to sponsor their own soil fertility, productivity and crop protection” (Altieri 2005). Agroecology focuses on creating ecologically sound and balanced agricultural systems. According to the theory “each crop field is an ecosystem in which ecological processes, such as nutrient cycling, predator/prey interactions, competition, commensalism, and successional changes occur” (Altieri 2005). Conventional agricultural practices tend to diminish or ignore the environmental milieu and ecological processes of which the agricultural system is a part.

The term ecosystem describes the set of unique relationships existing between the populations of organisms within. Interactions and relationships occur on many levels within and between ecosystems and occur locally, regionally, or globally. Physical components (both living and non-living components such as plants, insects, animals, soil, light, water, and temperature) of ecosystems have particular relationships that together take part in dynamic processes. Every community is a unique response to its particular environmental factors and the interactions between populations of species. Natural ecosystems differ from agricultural ecosystems in that they are able to regulate themselves and recover from disturbances. The challenge in creating sustainable agroecosystems is one of achieving natural ecosystem-like characteristics while maintaining a harvest output. Biodiversity (the number of species of plants, animals, and microorganisms present in an ecosystem) enhancement is one of the key strategies of sustainability. Agricultural practices that encourage biodiversity include crop rotations, cover crops, and intercropping, as well as planting hedgerows/windbreaks and perennial borders.

In order to support biodiversity, encourage development of ecosystem services, and create a truly sustainable world it is imperative to adopt a more holistic view of the environment. We (human society) need to locate ourselves within ecosystems and the environmental matrix of which we are a part. The “landscape matrix” approach of conceptualizing ecosystems is an effective strategy. People, homes, communities, industrial areas, agricultural regions, etc. all become part of a vast networked complex of ecosystems. We can start to understand that, as shown in Figure 5 there are many ecosystems in the world, some very large with huge spheres of influence such as the icecaps or tropical rainforest and some very small, such as a tiny rural cemetery with a patch of native prairie. The diagram illustrates that there are myriad of interactions in the environment; actions in one ecosystem affect ecosystems in other regions and individual actions often cause a chain of effects unknown to the original actor. The “structure” of an ecosystem, or simply put how it looks makes it relatively simple to see other ecosystems as separate entities, and fail to recognize the processes and functions occurring within and between ecosystems.

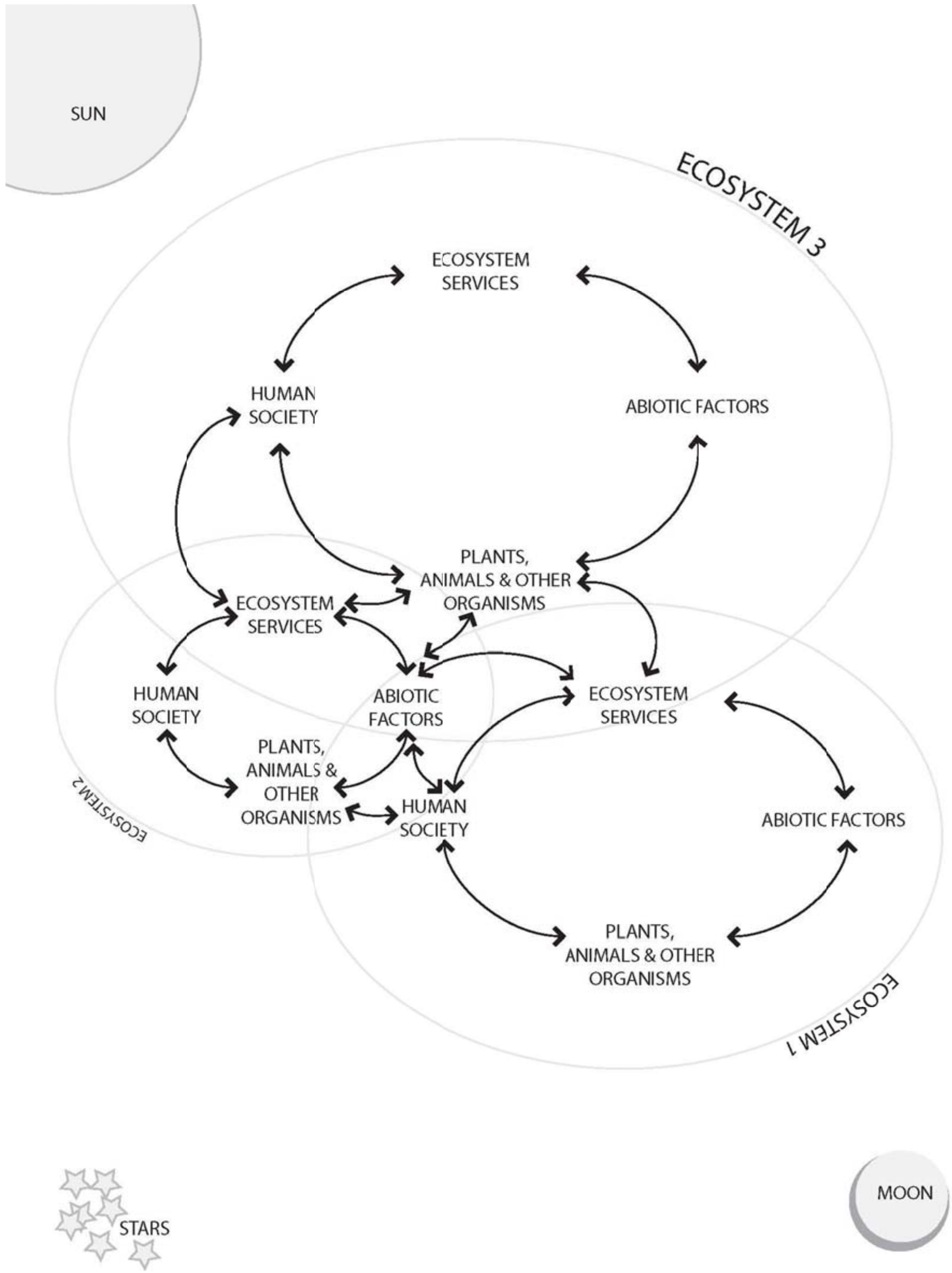

Figure 5. Ecosystem Concept (diagram by author).

CHAPTER 4: LANDSCAPE DESIGN

Integrating these ideas into the landscape will require foresight, planning, creativity, inspiration, and collaboration among many disparate groups. The field of landscape design is uniquely positioned to play a key role in this process, being a "common ground for scientists and practitioners to bring scientific knowledge into decision making about landscape change" (Nassauer and Opdam 2008). Landscape designers have a broad-based education, generally required to take courses in ecology, landscape history, site engineering, and are trained to consider the psychological and cultural aspects of design, and as such are vital to any multi-disciplinary team visioning future landscape scenarios. It is through this visioning process that collaboration, communication, idea generation and the inspiration can occur to stimulate dialogue, action and implementation. In particular, landscape designers and planners are trained to create dynamic multi-functional environments, sensitive to the needs of residents, native species and habitats, and ecosystem services.

In the visioning process, it is important to be sensitive to the fact that these farms and rural landscapes aren't abstract objects, but homes and livelihoods, representing generations of hard work. It is also important to recognize that these landscapes aren't intentionally unsustainable or carelessly created. Those working the land were responding to science, government, economic pressures and an agricultural aesthetic that they and their community believe in. In order to transition from the past to the future, and gain the support of rural communities and farmers it will be necessary to mesh the existing aesthetic with the potential future scenarios to demonstrate that these communities and their way of life have a place in this new sustainable future.

Cultural preferences and values play an important role in the commonly held perception of the agricultural aesthetic and the acceptance of sustainable agricultural practices. Many farmers object to sustainable practices because they conflict with their accustomed agricultural aesthetic. Landscape architect Joan Nassauer researches the aesthetic dimension of sustainable landscapes and differentiates two types of stewardship practiced by farmers- *neatness* and *environmental care*. Many conventional farming practices demonstrate good stewardship, including mowed edges, mown grass waterways, and lack of weeds. These practices may indicate care but are not necessarily environmentally friendly. Increasing plant diversity by leaving some weeds and not mowing edges and waterways on farmlands may be more environmentally friendly practices but are not as accepted because they conflict with understood notions of care and stewardship (Nassauer 1989). Michael Urban, professor of geography at the University of Missouri, has researched the values and ethical beliefs that determine management practices of farm drainage-ways in Central Illinois. His research found that farmers engage in many practices that they know can harm the environment, endanger species, and have no economic benefit because it looks nice (Urban 2005) i.e., demonstrates care.

The aesthetic preference of neatness is largely cultural and deeply embedded in our collective psyche. Environmental conservation proposals that do not take this cultural aesthetic into consideration are weakened and less likely to have broad appeal (Howett 1998). By creating a new agricultural aesthetic more aligned with traditional notions of aesthetics, the agricultural landscape can be imbued with a sense of value and worth beyond that of the present functional view of the landscape used solely for the production of crops.

In addition to neatness, both scenic quality and stewardship are elements of our culturally preferred aesthetic (Nassauer 1989). “Scenic quality” is an inherent geomorphologic feature while neatness and stewardship are human influenced features. In an agricultural landscape, neatness and stewardship are the direct result of care for land and reflect farmers’ hard work and dedication. The reflection of hard work and care in a landscape describes a different and deeper emotional content than that of sensual delight or engagement. The term “landscape affect,” describes this “broader range of emotions or feelings attached to ideas, places, or objects” (Thayer 1989, 103). Affect explains the sense of pride a farmer feels when reflecting upon his straight, weed-free rows of corn, well-mown grass field edges and waterways, and straight, brush-free drainage ditches. Affect also explains our positive response to such landscapes from the knowledge that the land is cared for, maintained and occupied. Affect also explains the difficulty in challenging these deeply embedded notions of landscape when encouraging the farmer to not mow, to allow diversity, and let the natural curves of the stream flow take over the crisp edges. Such a suggestion is akin to asking him to abandon his land and be seen as lazy by the community.

Thus, it is important to create ecological landscapes that will ease the farmer into a new landscape aesthetic. To do this Nassauer suggests using the norms of cultural aesthetics to design sustainable landscapes to create images that would be aesthetically pleasing. If they are not aesthetically pleasing they are less likely to be appreciated and upheld by the farmer or the community (Nassauer 1995). “The language of form that I believe that my neighbor understands” is the form that is expressed in the landscape and is used as a tool to communicate with neighbors and generate approval (Nassauer 1995, 162). The language of forms that can be utilized in the design of ecological landscapes are those visible throughout the countryside: freshly painted white fences, birdhouses in meadows and contour plantings. The inclusion of flowering plants in hedgerows and other natural areas of the farm, as well as selective mowing strategies are other means of making an agricultural landscape more sustainable (Nassauer 1989). Just a few such elements within a wilder, more ecologically sound environment will signify human presence and care for the landscape.

One of the largest obstacles to implementing biodiversity conservation throughout the state is that most land is privately owned. As a result individual farmers are burdened with responsibility to conserve and protect native biodiversity and provide vital ecosystem services. While farmers indeed need to implement agro-biodiverse practices and provide ecosystem services to improve agricultural sustainability, the conservation of native biodiversity should be overseen and guided by a larger, public entity. A recent study of county and municipal planning agencies in three separate regions of the U.S. indicated relatively little concern for biodiversity preservation in local and regional planning processes (Miller et al. 2008). Regional planning in rural areas is most often targeted at growth and service management. In reviewing available regional plans for Central Illinois counties, it was notable that in no plan was quality of agricultural landscapes, conservation of biodiversity and ecosystem services, or sustainability of agricultural practices mentioned. While this may not historically be under the jurisdiction of regional planning agencies it is unclear who is responsible. As biodiversity is a public good providing ecosystem services that benefit society as well as farms. Biodiverse areas can also provide other public amenities such as recreation, cultural and scenic amenities. A government sponsored approach would have the ability and power to implement cohesive statewide projects that could provide essential connectivity between impoverished ecosystems as well as to potentially collaborate with adjacent states to create regional corridors for migrating species through disconnected regional ecosystems.

Landscape design and planning services can be of significant value when applied at the regional level. The three local and regional planning agencies in the aforementioned study replied that they frequently collaborate with planning agencies in adjacent regions, but rarely for the purpose of biodiversity conservation (Miller et al. 2008, 61). This type of regional planning and collaboration is vital for the creation of regional networks of biodiversity.

Landscape design and planning working at this scale can also improve the aesthetic value of these regions. It is common for aesthetics to be addressed in city and urban planning. City plans commonly provide guidelines to ensure a perceived quality of life for its residents. Zoning regulations, tree planting guidelines, set-backs are examples of tools commonly used in city planning to ensure aesthetic quality. The tools for planning agricultural regions may differ and could include designation of agricultural buffers, wildlife conservation areas, greenway planning, and important locales for provision of ecosystem services. As agricultural landscapes are homes to people as are cities, it is as important to ensure quality of life for residents of rural communities. As noted by planner Kevin Lynch, in his timeless book *Managing the Sense of a Region*, “the human experience of the landscape is as fundamental” as any other factor (economics, transportation, politics, etc.) in the planning process (1976, 4).

CHAPTER 5: CENTRAL ILLINOIS

The Illinois government has taken a step toward the restoration and conservation of native biodiversity with the publication of the *Illinois Comprehensive Wildlife Conservation Plan and Strategy,* commonly referred to as *the Illinois Wildlife Action Plan* in 2005. This plan was spearheaded by the Illinois Department of Natural Resources in order to qualify to receive state and federal funding for wildlife conservation and restoration throughout the state. The plan was developed with the assistance of many local, state and national organizations, including The Nature Conservancy, Ducks Unlimited, the Sierra Club, the University of Illinois, Illinois Department of Agriculture, and many others (IDNR 2005). The document couples the species that are threatened or endangered within the state to their habitat needs and quantifies acreage necessary to meet the goals of conserving and restoring native species to stable levels. Though not directly pertaining to agriculture the document considers agriculture and crop fields as a very important ecotype in the state. It recognizes that agricultural systems must become enmeshed with native ecosystems in order to fully realize environmental and agricultural sustainability and conserve native biodiversity. The *Wildlife Action Plan* is organized by Natural Division, fifteen regions in Illinois defined according to biological and geological features (Wildlife Action Plan 2005). This chapter focuses on the Grand Prairie region which primarily covers Central Illinois east of the Illinois River (Figure 6).

Prior to settlement the Grand Prairie region was a vast area of tall-grass prairie. Land cover information compiled by the University of Illinois' Natural History Survey shows both current (Figure 7) and pre-settlement (Figure 8) land cover characteristics for Illinois.

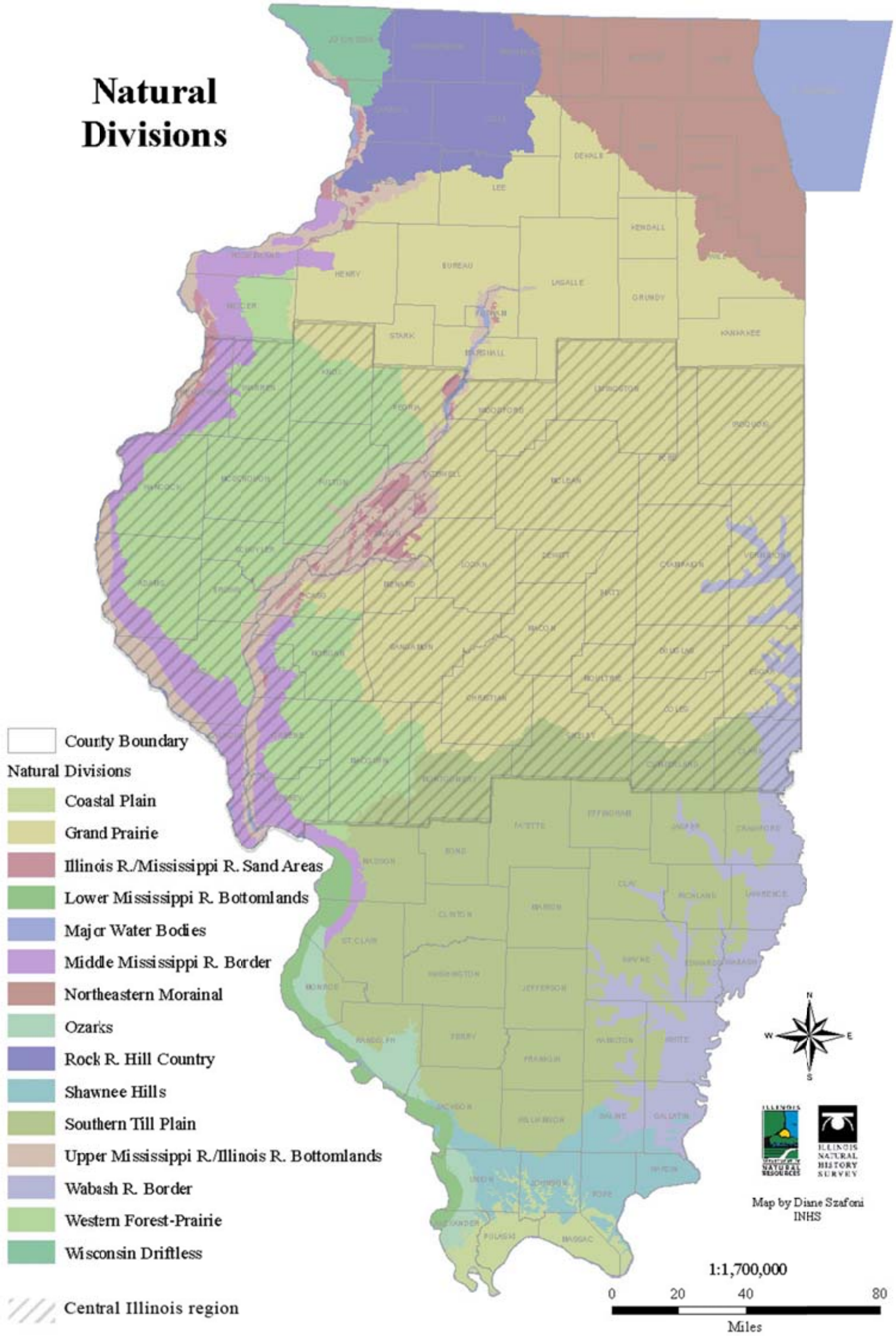

Figure 6. Natural Divisions of Illinois with Central Illinois region highlighted (Natural Division map courtesy Illinois Department of Natural Resources, http://dnr.state.il.us/ORC/WildlifeResources/theplan/mapfiles/natural_divisions.jpg)

A comparison of these maps shows that virtually all prairie was converted to agriculture in the Grand Prairie region and throughout the state. Prior to settlement there were extensive forested areas along river and stream corridors with fingers of vegetation connecting to form networks. At present, about 12% of Illinois is covered in forest- one of the largest categories of remaining natural areas in the state (IDNR 2005, 37). This is likely due to a large percentage of forests located in floodplains immune to conversion to agriculture. Due to excessive fragmentation the forests have been invaded by non-native species and reportedly no forests statewide are currently capable of serving as population sources. Fire suppression over the past half-century has allowed maples to replace oaks (a valuable wildlife species) as the dominant canopy type in many forests.

Savannas formed a transitional vegetation type between forest and prairie. Their extent and distribution was regulated by climate, topography and fire. Central Illinois' savannas are defined as having more than one mature tree per acre but less than 50% canopy cover. Since settlement over 99.98% of this native ecotype has been destroyed. The pre-settlement information was gathered during the original land surveys of Illinois that began in the early 1800s in southern Illinois, continued northward and were completed by 1850 (http://www.inhs.illinois.edu/cwpe/maps/poster2.gif accessed August 2010). At the time of the survey, the "savanna" land cover type was not yet clearly defined and was originally termed "barrens" (Figure 8). According to the original land cover map, there were very few barrens described during the land survey. As this land cover type is currently recognized as a predominant vegetation type having existed prior to settlement, this discrepancy may be due to individual surveyors misclassifying land cover due to incomplete knowledge. It may be

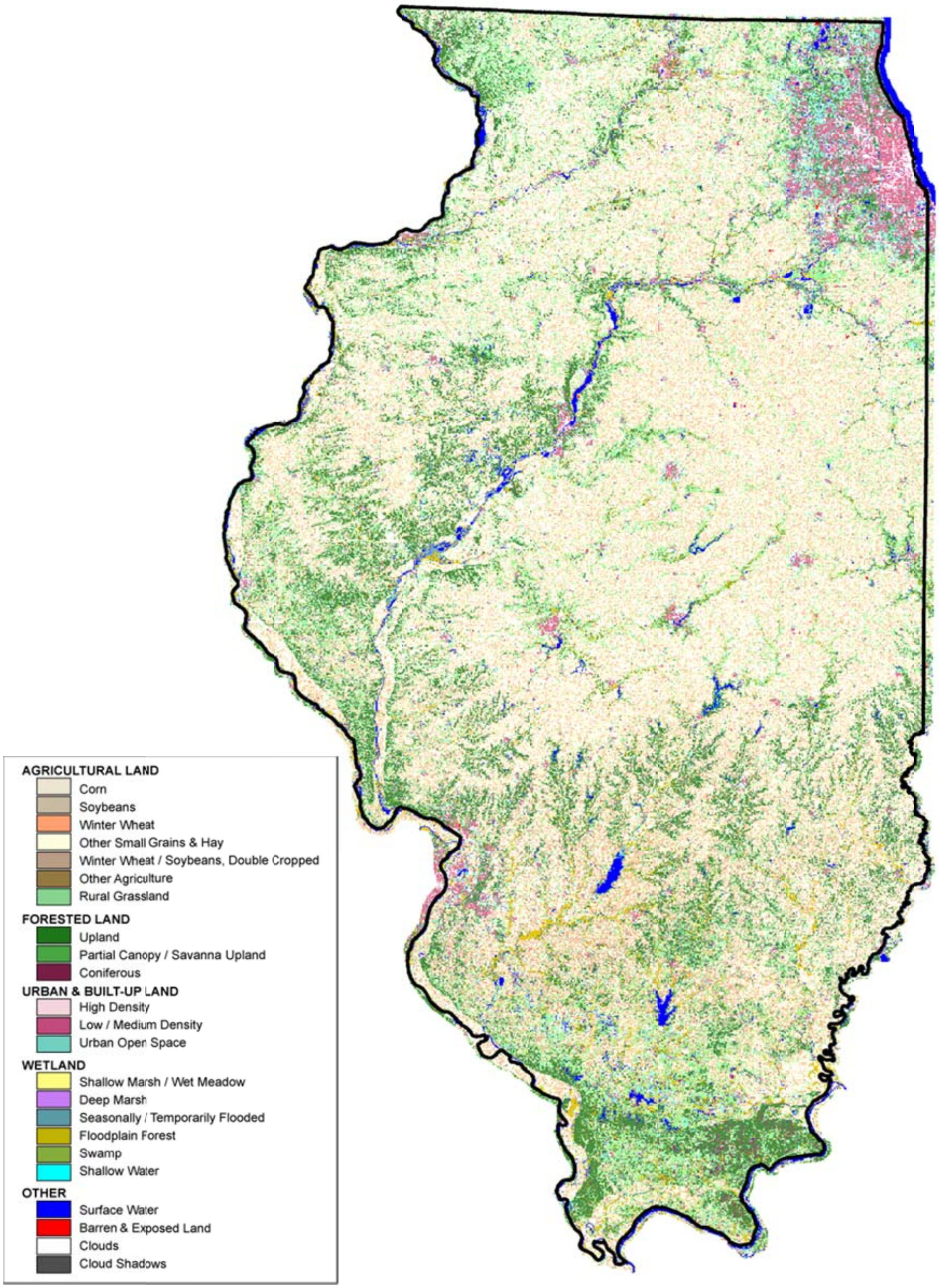

Figure 7. Current Statewide Land Cover. (map courtesy Illinois Natural Resources Geospatial Data Clearinghouse, http://www.isgs.uiuc.edu/nsdihome/webdocs/landcover/nass07.html)

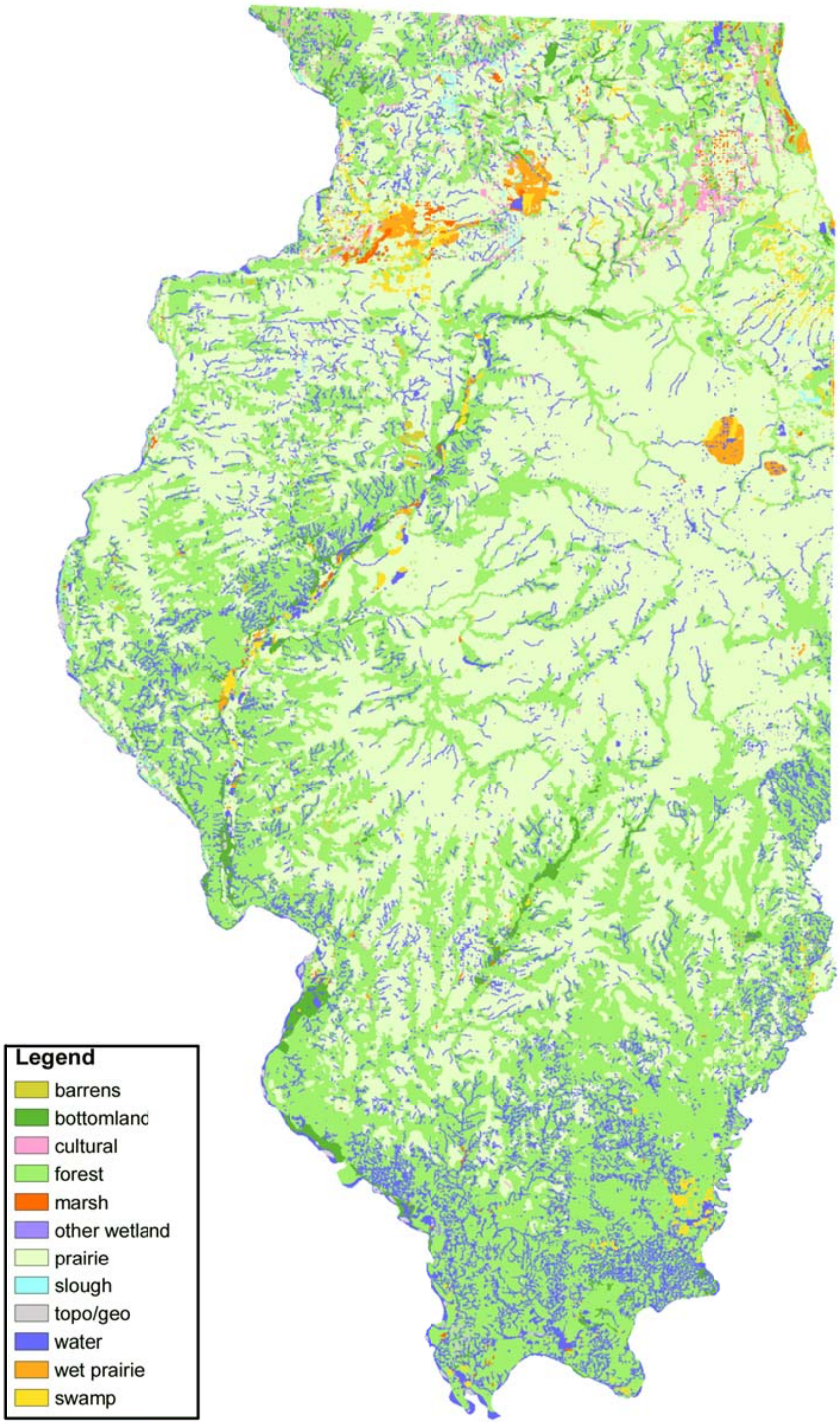

Figure 8. Pre-Settlement Land Cover (approximately 1850) (map courtesy Illinois Natural History Survey, http://www.inhs.illinois.edu/cwpe/maps/glo.html)

assumed that regions of forest and prairie in the pre-settlement map include what is currently referred to as savanna.

Natural drainage throughout much of the Grand Prairie region was poor creating marshes and prairie potholes. Wetlands throughout the state have been reduced by 90% due to draining, filling clearing and urban development (IDNR 2005, 38). Streams were often associated with wetlands and were originally sinuous as they meandered through the flat landscape. Along with the draining and filling of wetlands for agricultural purposes most of Illinois' streams in agricultural regions have been straightened, levied and cleared of protective vegetation to encourage quickly draining farms.

Understanding the vegetation type and distribution throughout the region can inform the restoration of biodiversity. Specific research regarding the ecosystem services and potential for use in agricultural biodiversity schemes of native plant species is scant. But, given the results of the Fiedler and Landis study of native plant species in Michigan, it would seem reasonable to conclude that native Illinois species would likely be as good, if not better suited to providing habitat, floral and nectar resources for insects and other wildlife desired for pest control and pollination. As noted earlier, these native species also provide habitat and resources for native species not targeted in agrobiodiversity schemes.

Figure 9 is a compilation of "resource rich" areas within the state of Illinois, as determined by the Illinois Department of Natural Resources (2001, 3) with publicly owned/managed lands in the state (http://www.inhs.uiuc.edu/cwe/gap/stewardship.htm accessed July 2010) to indicate the amount of land specifically managed to conserve biological diversity. A large percentage of natural or resource rich areas are found along river and stream

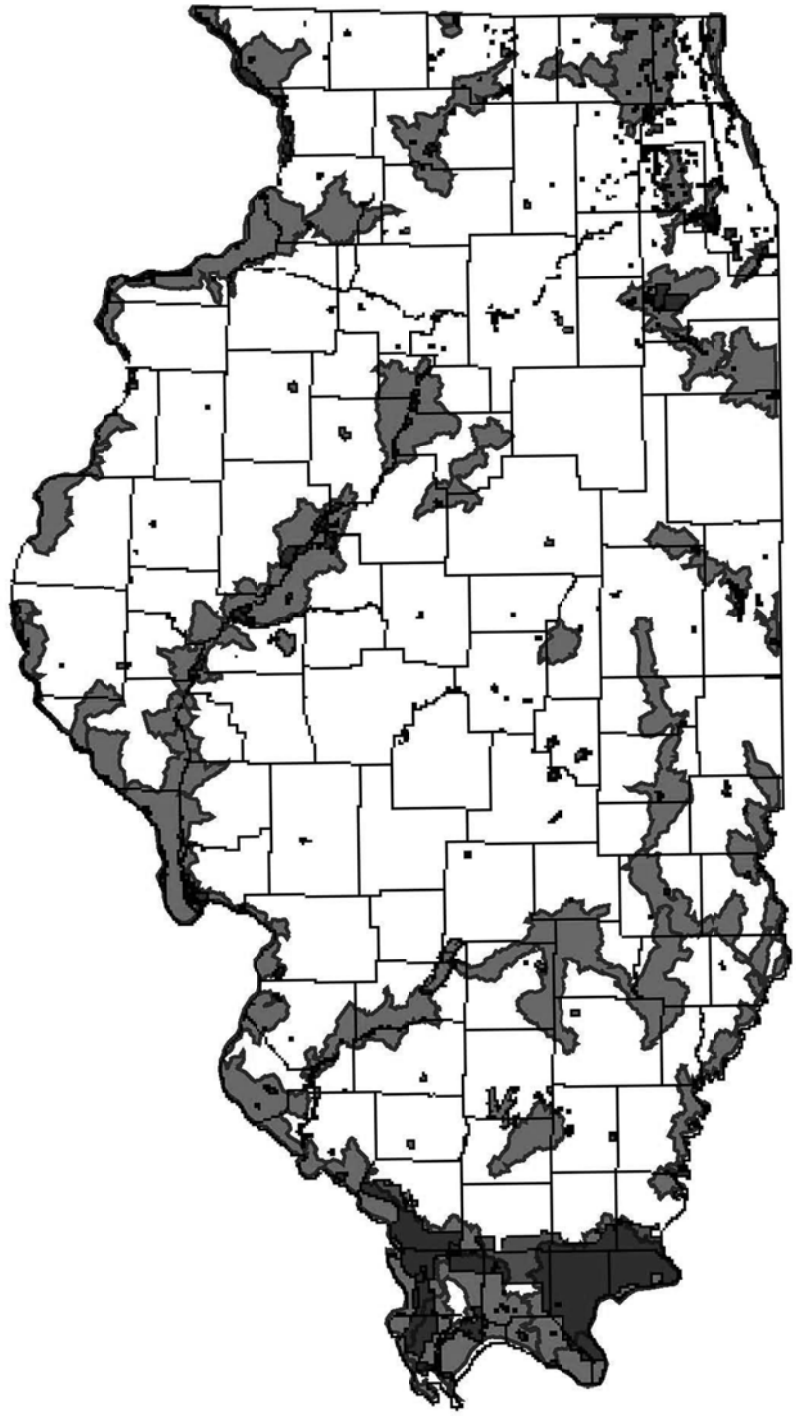

Figure 9. Natural Areas in Illinois. (Map overlay of *Public Lands,* from The Illinois Department of Natural Resources http://www.inhs.uiuc.edu/cwe/gap/stewardship.htm and *Previously Identified Conservation Areas,* from The Illinois Natural History Survey http://dnr.state.il.us/ORC/WildlifeResources/theplan/mapfiles/Previously_Identified_Priority3.jpg.)

corridors due to (as discussed previously) these areas being impossible to convert to farmland. There is a surprising amount of natural areas in the Chicago metropolitan region (upper right of state) often greater than found in rural areas. Biodiversity restoration projects throughout the state should work toward increasing the amount of natural areas throughout the state as well as creating networks of existing and future areas of natural vegetation.

REGIONAL SCALE

Tazewell County (Figure 10) is located in Central Illinois and is somewhat atypical of most counties within Central Illinois in that it has a much larger percentage of natural areas, though of the state's ten watershed districts the Mackinaw (including Kankakee and Vermillion Rivers) has the most cropland (IDNR 2001). The Mackinaw is a major tributary of the Illinois River and currently experiences one of the highest sediment yield rates of all tributaries (IDNR 2001). This is primarily due to having been channelized, straightened and leveed with much natural vegetation removed. Farming activities often occur adjacent to the river channel. This region was selected to illustrate some of the ideas discussed in the paper thus far. Figure 11 illustrates a region within Central Illinois (approximately 45 miles northeast of Springfield) showing the river and stream networks with a brief analysis of the region. The diagram indicates many areas along the Mackinaw river channel that have been leveed and cleared and are under production. Removing the levees and restoring native vegetation will allow the river to move more freely throughout the floodplain during peak flows enabling deposition of sediment prior to entering the Illinois River. Vegetation along the river and stream channels in the region are highly convoluted and fragmented. Smoothing the edges and combining

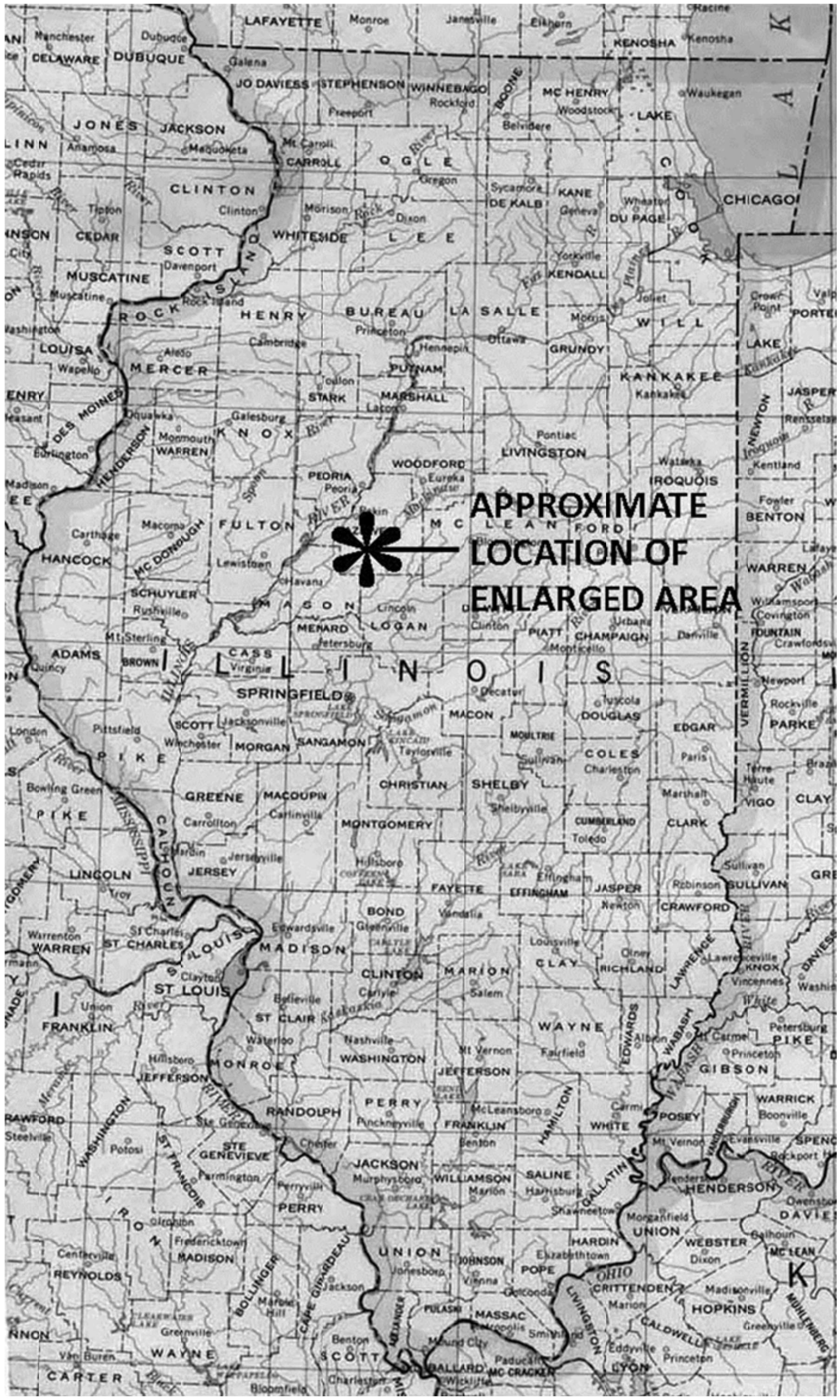

Figure 10. Tazewell County and approximate location of enlarged area. (Map courtesy The University of Texas at Austin, http://www.lib.utexas.edu/maps/illinois.html)

disparate regions of natural vegetation will support native biodiversity by providing larger regions of interior habitat. Many smaller stream channels permeate outlying agricultural regions and wide vegetated buffers should be added to these channels to intercept runoff and decrease nutrient and sediment loads in the streams and rivers. Intervening agricultural regions (as in the southeastern region) are typical of this region and much of Central Illinois. In this area large contiguous fields of corn and soybeans have little vegetation interspersed throughout the region. Adding buffers of native vegetation along and between field boundaries will provide habitat and ecosystem services for agricultural regions, contribute to regional ecosystem services, and create networks of natural areas supporting native biodiversity. Figure 12 indicates the enlarged area shown in the following two diagrams (Figures 13 and 14) in which these ideas are explored in greater detail.

Figure 13 shows the existing agricultural region adjacent to woodlands that surround a stream corridor that drains into the Mackinaw River. As shown in the diagram the edges of the existing vegetation is highly convoluted and an overlay expands the existing vegetation to create a much less convoluted edge condition, thus supporting more high quality interior habitat species as suggested by the literature. Figure 14 shows this vegetation in the context of a proposed improved agricultural region showing networks of prairie, savanna, and woodland interspersed among agricultural fields. The agricultural component largely remains composed of corn and soybeans but with an additional third agricultural type (described as other) interspersed in the region. “Other” agriculture could include orchards (fruit, nut, timber) or vegetable production. Perennial type agricultural production (such as orchards) placed in more

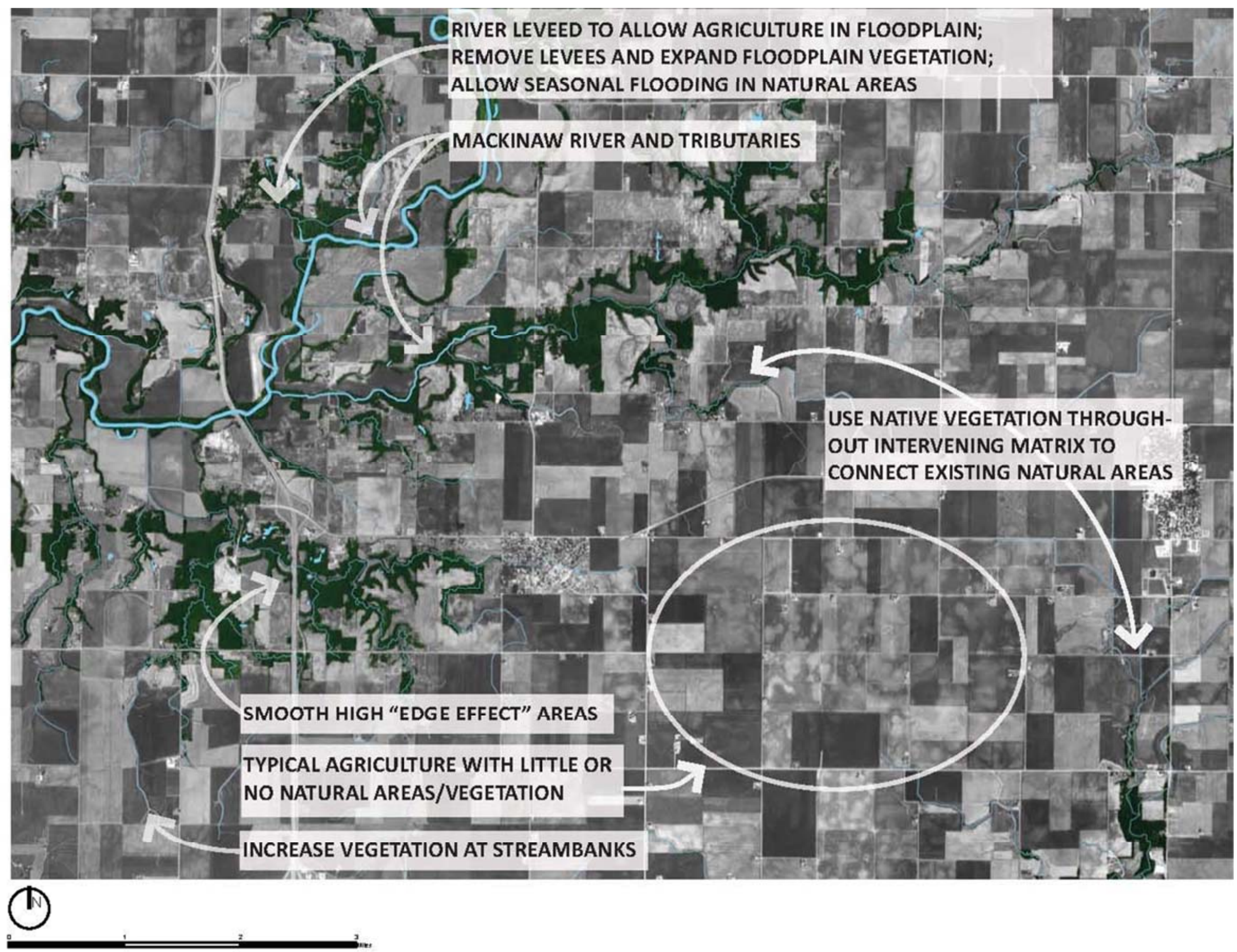

Figure 11. Analysis of region in Mackinaw River watershed in Tazewell County

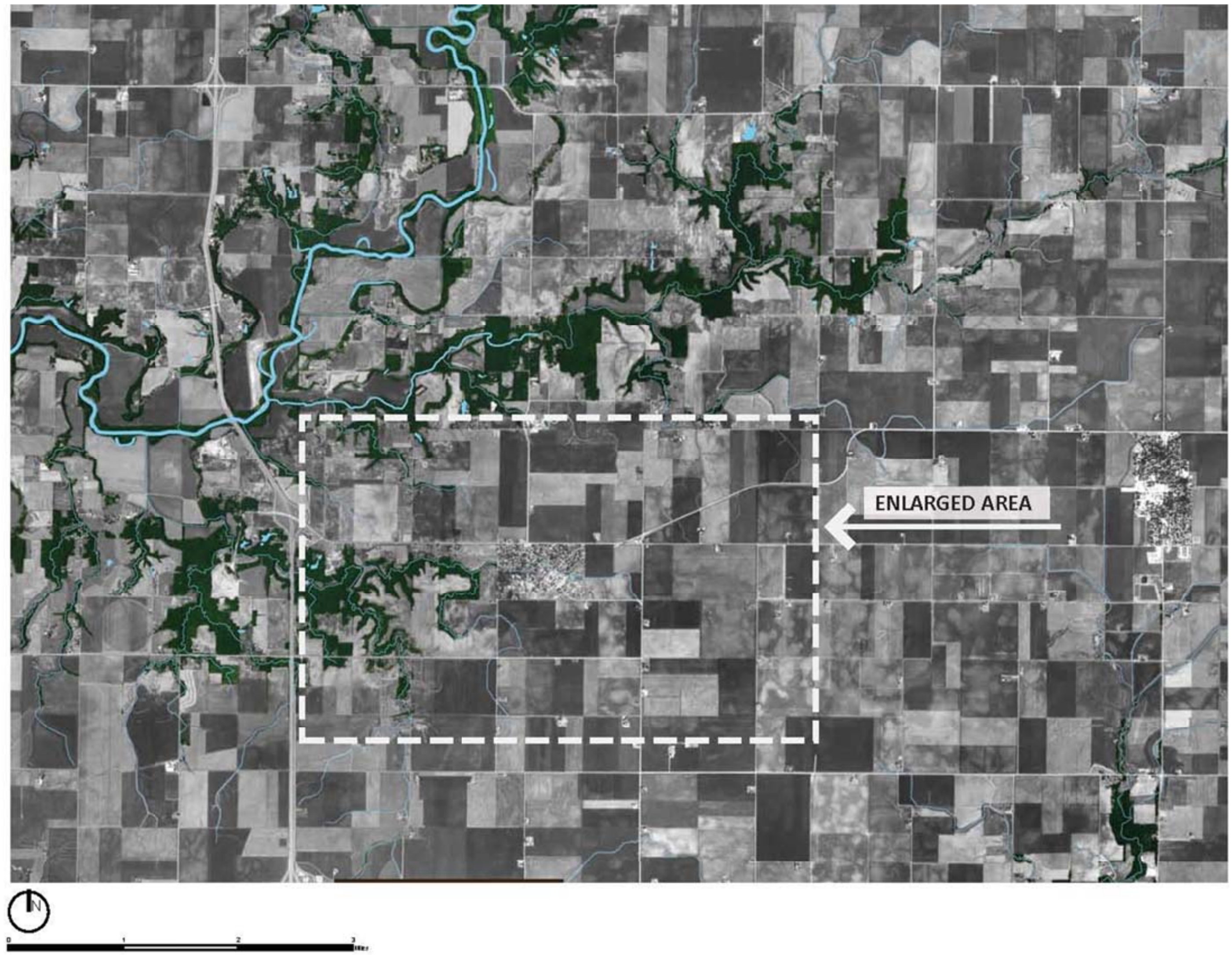

Figure 12. Enlarged area shown in Figures 13 and 14. (2005 Illinois Digital Orthophoto Quarter Quadrangle Data courtesy Illinois Natural Resources Geospatial Data Clearinghouse, Illinois State Geological Survey, http://www.isgs.uiuc.edu/nsdihome/webdocs/doq05/ with overlay by author)

sensitive regions (adjacent to stream corridors) could help improve habitats and reduce sedimentation from waterways. Incorporating alternative agricultural crop production increases diversity in the agricultural matrix supporting a wider range of biodiversity.

The proposed agricultural matrix shown in Figure 14 was informed by the pre-settlement vegetation in Illinois (Figure 8) using vegetation patterns that occurred “naturally” to guide re-establishment of vegetation. The original vegetation pattern suggests that the largest proportion of forest occurred along rivers and major stream corridors. Distance from water as well as elevation increased the amount of prairie vegetation. Savanna was treated as an intermediary between the two cover types. Referring to Figure 14, forest cover is shown adjacent to stream corridors with connections created through the agricultural landscape. Savanna is shown as an intermediary between prairie and forest with prairie shown as the predominant vegetation type re-established in the region.

The proposed vegetation generally follows existing farming patterns visible in the satellite photo (Figure 13). Re-vegetated areas are shown along divisions occurring between fields, along roadsides, and along stream corridors. The scale of the agricultural plot and the relative proportions of agriculture to natural areas is an important consideration but not addressed in these illustrations. The *Illinois Wildlife Action Plan* proposes acreage of land to be naturalized necessary to return biodiversity to sustainable levels but these numbers apply to the entire Grand Prairie region and have not been proposed at the county or regional level, much less at the individual plot scale. It is unclear if the re-vegetated areas shown in Figure 14 relate to the acreages proposed by the *Illinois Wildlife Action Plan* or if such a strategy as shown

Figure 13. Existing Central Illinois Landscape with proposed Forest Habitat edge smoothing (2005 Illinois Digital Orthophoto Quarter Quadrangle Data courtesy Illinois Natural Resources Geospatial Data Clearinghouse, Illinois State Geological Survey, http://www.isgs.uiuc.edu/nsdihome/webdocs/doq05/ with overlay by author.)

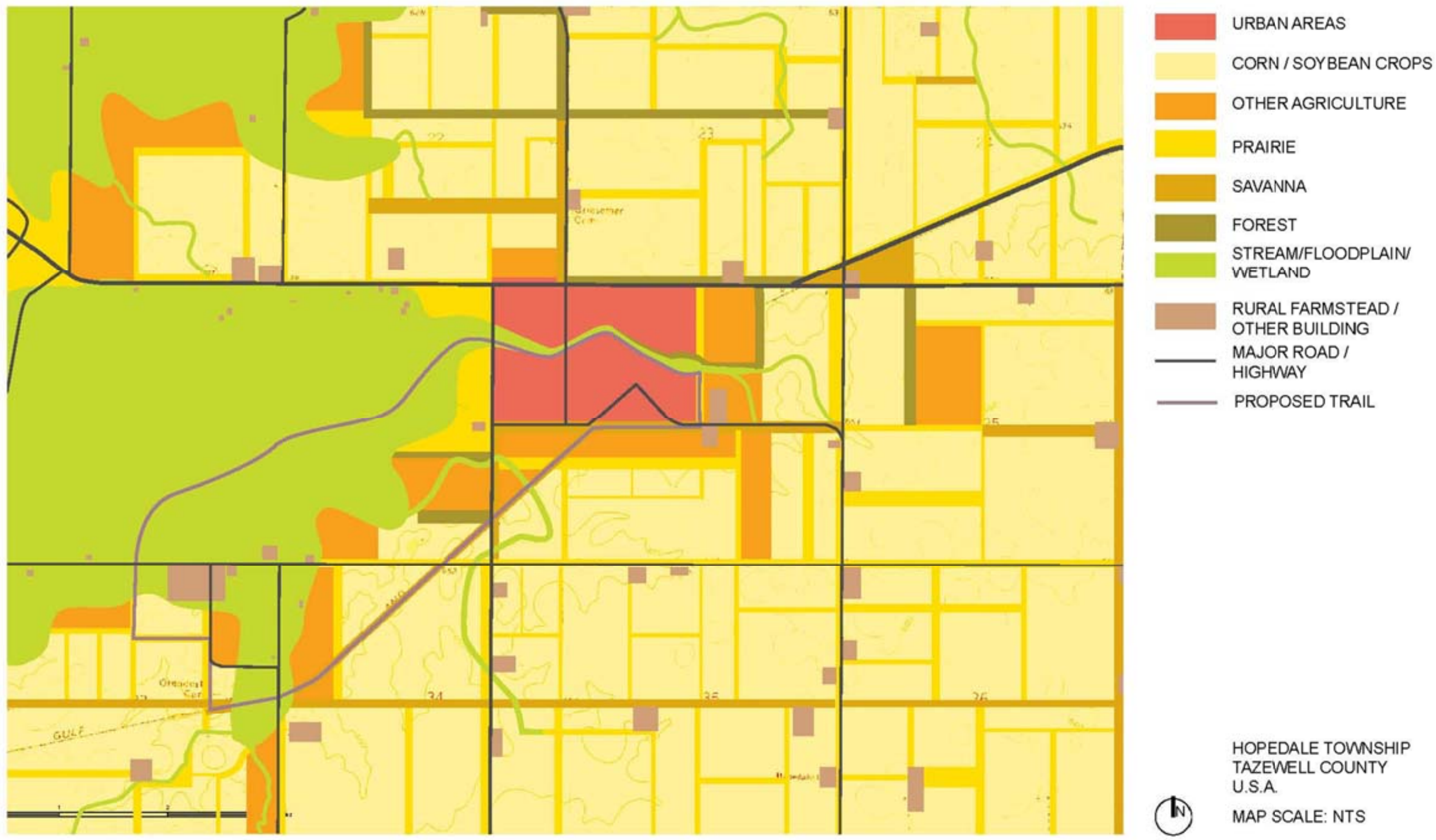

Figure 14. Proposed Central Illinois Landscape. (2005 Illinois Digital Orthophoto Quarter Quadrangle Data courtesy Illinois Natural Resources Geospatial Data Clearinghouse, Illinois State Geological Survey, http://www.isgs.uiuc.edu/nsdihome/webdocs/doq05/ with overlay by author.)

were to be applied at the regional scale if the quantity of re-vegetated areas would be lesser or greater than that proposed by the *Wildlife Action Plan*.

Another element incorporated into the Proposed Landscape of Central Illinois (Figure 14) is a pedestrian trail to the south and west of the "urban area." The trail partly follows an abandoned railroad right-of-way, traversing adjacent forested areas before connecting back to the town's existing natural and recreation areas. Indicating places for people and ways for people to interact with the broader landscape is an important component of sustainable, diverse landscapes.

PLOT SCALE

The vignettes in Figures 15, 16, 17 and 18, show various land cover adjacencies that might occur as indicated in Figure 14. The vignettes focus on the establishment of vegetative diversity, as plant diversity is the foundation for a biodiverse ecosystem as discussed in Chapter 2. The five types of plant communities native to Central Illinois are shown: woodland/forest, savanna, prairie, wetland, and stream/river. For the sake of comparison, Figure 16 indicates an existing condition with crop production area maximized. The comparison strongly illustrates the starkness of monocultural crop regions and its' limited potential for supporting wildlife compared to the proposed vignettes.

It should be noted that the diagrams are not to scale, and are intended to illustrate types of habitats and specific plant species suitable for this region. When planting species to be used for specific purposes the effective area (or range) of individual species must be taken into account. For example, plants can be used to attract predaceous insects for the biological control of crop pests. Each insect species' has a specific "home range," the distance the insect generally will travel between its' nest and food resources. This suggests that for effective biological control of crop pests agricultural field size and associated native plantings should be correlated with target predators, thus the actual size and distance between habitats is dictated by the crop pest/predator of interest.

Plant species information for the various habitats specific to Tazewell County, Illinois was compiled from a number of sources, primarily the USDA Plants Database (http://plants.usda.gov/), the Illinois Plant Information Network (ILPIN) (http://www.fs.fed.us/ne/delaware/ilpin/ilpin.html), Illinois Wildflowers (http://www.illinoiswildflowers.info/index.htm), and the Illinois Natural History Survey (http://www.inhs.uiuc.edu/~kenr/corridors.html). These websites provided extensive information regarding native plant species of Illinois. The Illinois Plant Information Network provides a great deal of information about Illinois plants including native range, general floral and faunal associations, bloom period and mode of pollination. The website listed over 900 species native to Tazewell County. This information was compiled with additional information regarding plant height, specific faunal species associated, and seasonal value to select species shown in the vignettes. These species shown would be particularly useful for re-vegetation strategies based on wildlife value, landscape (aesthetic) value and availability of nursery stock and/or seed (the latter based on personal knowledge and experience).

Introduction of perennial and woody species adjacent to crop plantings supports diversity of native species as well as potentially provides ecosystem services to adjacent crops, such as bio-control of crop pests and reduced soil erosion. These diagrams show only a handful of available species as they are intended to primarily illustrate the dramatic improvement of

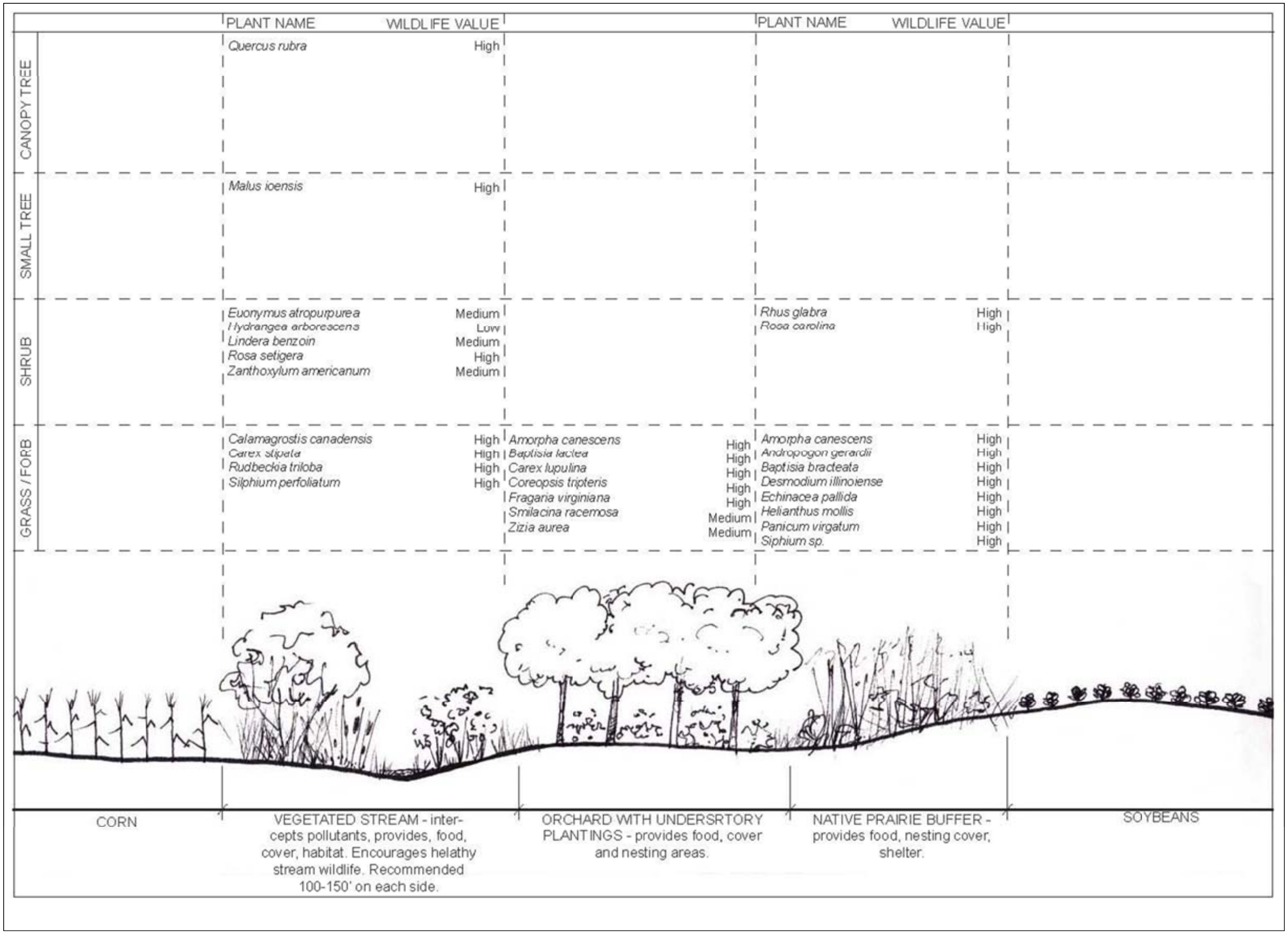

Figure 15. Stream / Orchard / Prairie and Agriculture Vignette. (Diagram by author.)

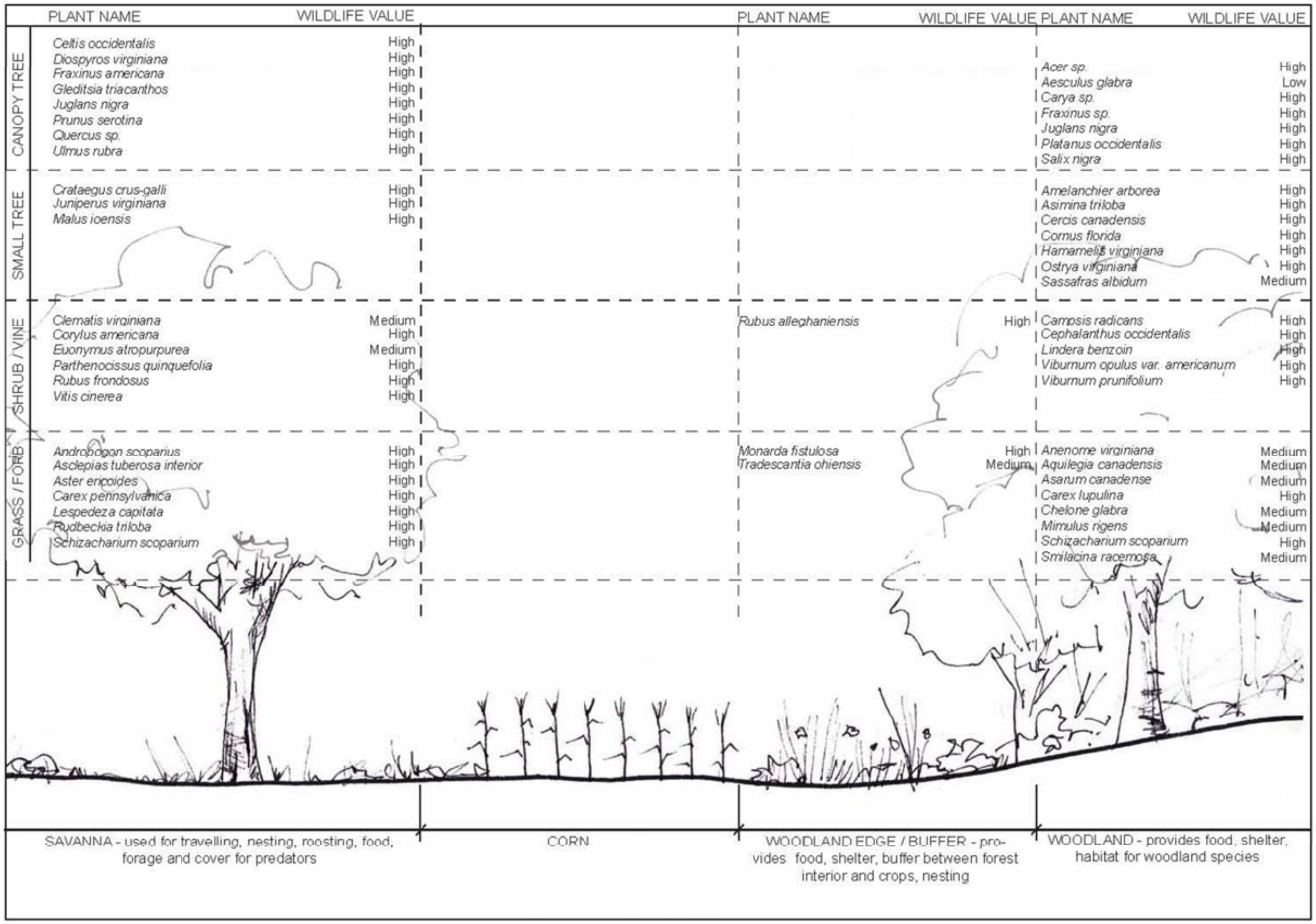

Figure 16. Savanna / Agriculture / Forest Vignette. (Diagram by author.)

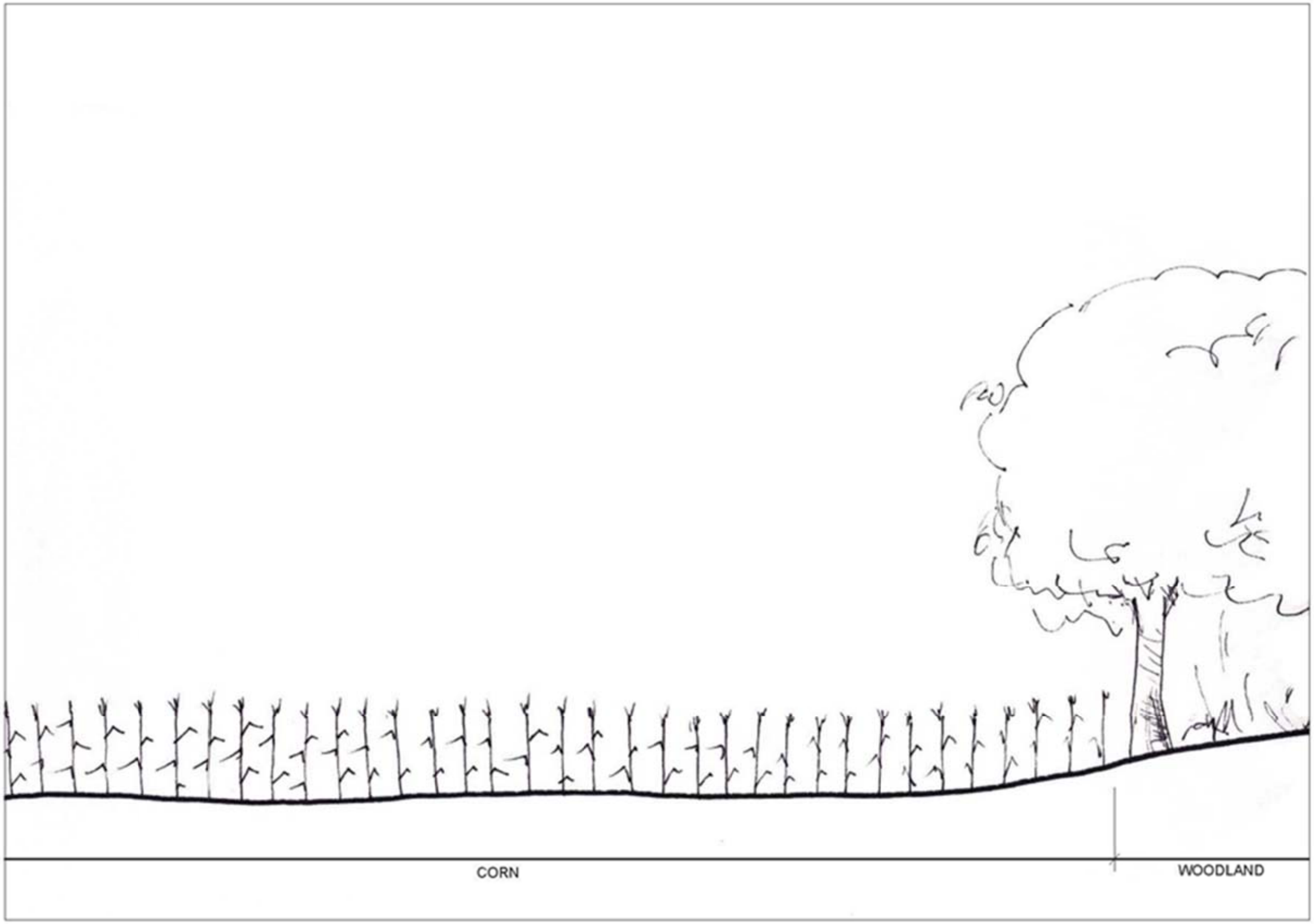

Figure 17. Agricultural region for comparison. (Diagram by author.)

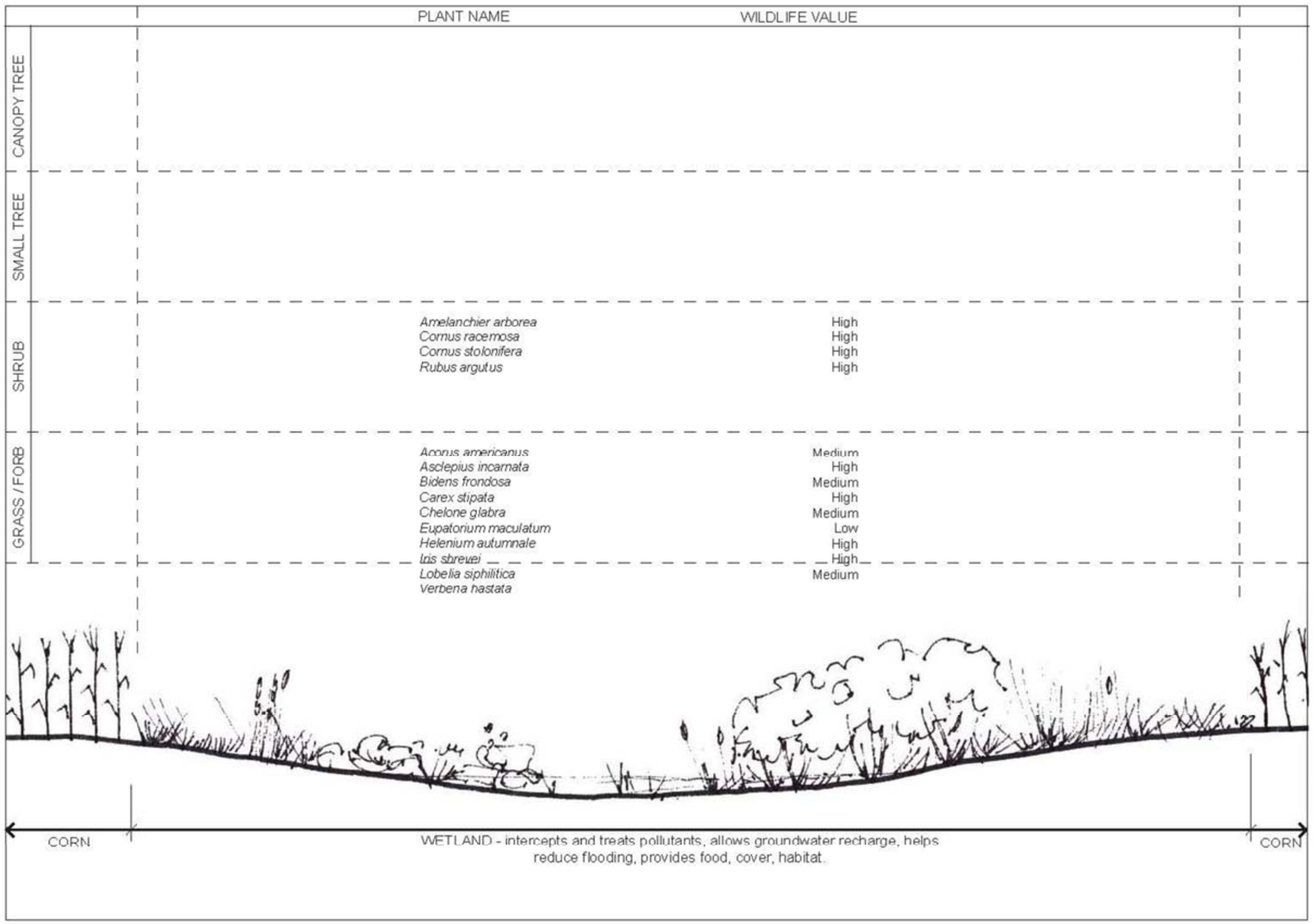

Figure 18. Wetland / Agriculture Vignette. (Diagram by author.)

Illinois plant species for provision of ecosystem services and this would be a valuable area of research. These planting selections were primarily chosen for wildlife value as well as the structural and temporal diversity of the plant palette. Structural and temporal diversity are different types of diversity in addition to species diversity. Consideration of the composition of the plant palette in these different dimensions is an effective strategy to ensure the development and sustenance of species diversity over time.

The diagrams illustrate structural characteristics of the species by organizing the plant species by canopy, small tree, shrub, and grass/forb. Increasing structural diversity generally increases the diversity of associated faunal species as different plants support different needs of wildlife species and/or different periods in the species' life cycle.

Figure 15 (Stream / Orchard / Prairie and Agriculture Vignette) indicates a stream or waterway within a production area and illustrates plantings that will improve the quality of the water as well as provide habitat for species. Vegetated waterways are common throughout the region, but mainly are vegetated with grasses that are regularly mowed. Incorporation different types of vegetation, as well as expanding the distance of waterways and stream banks to the recommended 100-150' width will greatly enhance interception of overflow, release of sediment prior to entering the waterway, absorption of excess nutrients and chemicals, and provide multiple resources for wildlife. Perennial agricultural schemes placed near waterways or stream corridors could also provide this benefit while also providing a productive output that would benefit the farmer directly. As illustrated, to provide the greatest benefit orchards should be planted with a cover crop. The cover crop would intercept runoff as well as host beneficial insect species. Prairie plantings of native grasses and forbs should be one of the most prevalent landscape types restored throughout agricultural regions, as indicated in Figure 14, as this was the most common landscape type prior to settlement indicating that this landscape typology is well-suited to this climate and native wildlife species are adapted to this landscape.

Figure 16 shows the savanna and forest landscape typologies with agricultural production between. As mentioned previously in the chapter, forested lands were largely associated with riverine systems and in upland landscapes the forest generally transitioned to savanna then prairie. The savanna is an intermediate landscape typology retaining features of both prairie and forest but with many species specifically adapted to this ecotype. Though it might be difficult to encourage farmers to plant trees in the middle of agricultural fields as they would take up more space and shade adjacent crops trees in the landscape provide food, shelter and cover for a great diversity of wildlife, including predatory birds such as hawks and numerous insect-eating birds and would likely prove highly beneficial in biological control of insect pests. Inclusion of forests in agricultural landscapes is also important as they provide connectivity, food, and shelter for wildlife unique to this ecotype. Forested regions can be established along waterways as well as selectively throughout the agricultural landscape. For instance a forested edge along farmsteads can also serve as windbreaks and snow fence protecting buildings and animals within the farmstead.

Figure 18 illustrates a wetland region within an agricultural context. As much of the land in Central Illinois is flat it by and large has to be artificially drained to accommodate modern agricultural practices. Removing artificial drainage and encouraging the formation of wetlands will not only provide important food and habitat for a great deal of wildlife (including many migratory species) but can reduce peak stream flows, aid sediment deposition and excess nutrient and chemical removal from agricultural runoff before re-entering stream corridors.

An important consideration regarding incorporation biodiverse plantings in the landscape for bio-control of pest species is the distance between plantings. Many insects and birds have a relatively limited range of movement. In Figure 14 the suggested re-vegetated areas are located along existing “breaks” in the agricultural landscape, where it is apparent from the satellite photo in Figure 13 that the planting regime changes. These suggested planting areas may or may not be close enough to coincide with species’ unique ranges of motion. The planting arrangement thus depends to an extent on the predaceous species being cultivated for the crop planted, and would be at the discretion of the individual farmer or land manager.

The preceding diagrams illustrate primarily structural diversity for the various landscape typologies. Species selection should also consider temporal diversity and how the landscape and resource availability for species changes over time. This is of particular value when trying to attract and maintain populations of pollinating or predaceous species to provide these ecosystem services to crop plants. In order to effectively *control* pests ideally these predaceous species need to be present to prevent pest outbreaks. Most often pests are only dealt with after an outbreak occurs encouraging a heightened response from farmers or land managers in order to control. By providing year-round habitat and food resources for wildlife can ensure permanent residency of beneficial species such that outbreaks may no longer occur. Temporal diversity is also an important consideration when planting for general biodiversity as the landscape and resource availability changes dramatically through the seasons.

To illustrate relationships between plant diversity and wildlife biodiversity, a series of seasonal food web diagrams were developed as shown in Figures 19, 20, 21 and 22.

The “spring” diagram (Figure 19) shows the importance of having perennial and woody species in the landscape as they will be already leafing out and flowering well before the farmer can even access the fields to plant crops in spring. These early resources attract pollinating insects encouraging them to locate nests nearby thus establishing resident populations of habitat and resource availability conferred by a relatively small increase in vegetative diversity. No research exists at this time to substantiate effectiveness of these (or any other) native insects available for providing ecosystem services. Established insect populations are a vital aspect for a healthy food web as they are important food resources for many species of birds and mammals, which are then also sources of food for species higher up on the food chain. Figure 20 (summer) starts to show how the landscape changes and how these changes effect species up the food chain. For instance, spring-blooming tree and shrub species have finished and summer-blooming species (largely grasses and forbs) are starting. Although the precise timing isn’t indicated in the diagram this can be a difficult period for pollen seeking insects if not enough early summer flowers aren’t available in the landscape. As mentioned earlier, pollinating insects tend to make their nests relatively close to food sources. If food sources disappear the pollinating insects will have to relocate nests closer to new food sources. At first this seems to be of little importance for the two primary crop species of Central Illinois (corn and soybeans) as they are wind-pollinated species. But most insects have several life stages and have different food requirements at different stages. For example predatory wasps (an important herbaceous insect predator) as adults rely on pollen for food (they are predaceous at their larval stage). There are also a number of bird species that rely on varying food sources depending on the season. The northern flicker for example, eats primarily ants and beetles during summer, but eats a variety of other insects during winter one of which is the corn borer, a major crop pest (http://bna.birds.cornell.edu/ accessed August 2010). Both examples (wasp and flicker) illuminate the importance of a diverse landscape to support faunal life cycles, and underscores why vegetative diversity is the foundation for biodiverse landscapes. Figure 21 diagrams a fall food web and again indicates shifts in resource availability. Few species are blooming at this time as seed and fruits are ripening. Insects that rely on pollen and nectar shift to producing larvae that will overwinter in various locations in the landscape (under tree bark, in soil, under leaf litter). Birds and mammals eat seeds that are high in fat and nutrients to help store energy for winter, migration or possible hibernation. Winter (Figure 22) is, not surprisingly a most resource-poor season as leaves and much fruit has fallen, soil organism activity has ceased, and insects have returned to larval stages for the winter. Migratory species have left but there are many species that stay in Illinois year-round (most tertiary consumers, cardinals, flickers, finches, and woodpeckers) and must have food resources available to sustain them. Many rely on remaining seeds on perennials and forbs, or less palatable fruits such as from the holly that are the last choice of many animal species. Larval insects can provide important protein sources for those that can reach them; hence the beaks of nuthatches, flickers and woodpeckers have evolved to penetrate trees to access the larval insects within.

As previously mentioned, these diagrams illustrate only a fraction of available species and interactions that might occur in an actual landscape. Capturing the complexity of food webs in a diagram is an immense task worthy of its own research endeavor. Illustrating this complexity in a diagram is also potentially overwhelming to the point where the information becomes meaningless to a layman or casually interested observer. The important aspects of the diagrams shown here are not illustrate actual ecosystem complexities but to demonstrate the importance of complex ecosystems in time and space. Illustrating temporal diversity in a diagram is also a complex task but this dimension is of critical importance to sustaining diversity in the landscape. Illustrating the relatively few ecosystem resources available to species during the winter months demonstrates the importance of maintaining cover and food sources during this season, and holds important management implications that will support biodiversity in the landscape. For example, a “clean” landscape approach where fields are tilled, field margins are mowed and shrubbery is cut back in the fall greatly reduces winter resources for wildlife. A less intensive management system is often a more wildlife-friendly approach.

One of the most significant objections to incorporating biodiversity in agricultural landscapes is the potential for introducing pests and weeds into the crop system thus requiring more intense management interventions. Though some existing research indicates that this is not the case there is little research available specific to Illinois. It is uncertain whether monetary losses due to reduced crop yield resulting from increased pest/weed outbreaks would be greater than the cost of expensive chemicals to abate these problems. It is likely (especially as costs of oil increase) that this is not the case, but again there is little research to substantiate this.

Additionally, it’s important to note that species as perceived as desirable or undesirable by humans may serve important ecological functions. For instance the maintenance of litter and groundcover in crop fields as well as field margins has been argued against by farmers because it potentially increases crop pest species. While this may be the case, it also enables the overwintering of beneficial insects that can balance these pest populations. These larvae overwintering in leaf litter can also serve as food sources to various overwintering birds and small mammals that find them, thus supporting greater wildlife diversity. There are other benefits to maintaining soil cover such as reduced erosion and increased soil microbial activity (thus increased nutrient recycling, soil organic matter and soil building). This underscores the complexity of natural ecosystems and that few simple cause and effect relationships exist in nature. What may seem as a simple management tactic may cause a web of other unintended or unknown consequences.

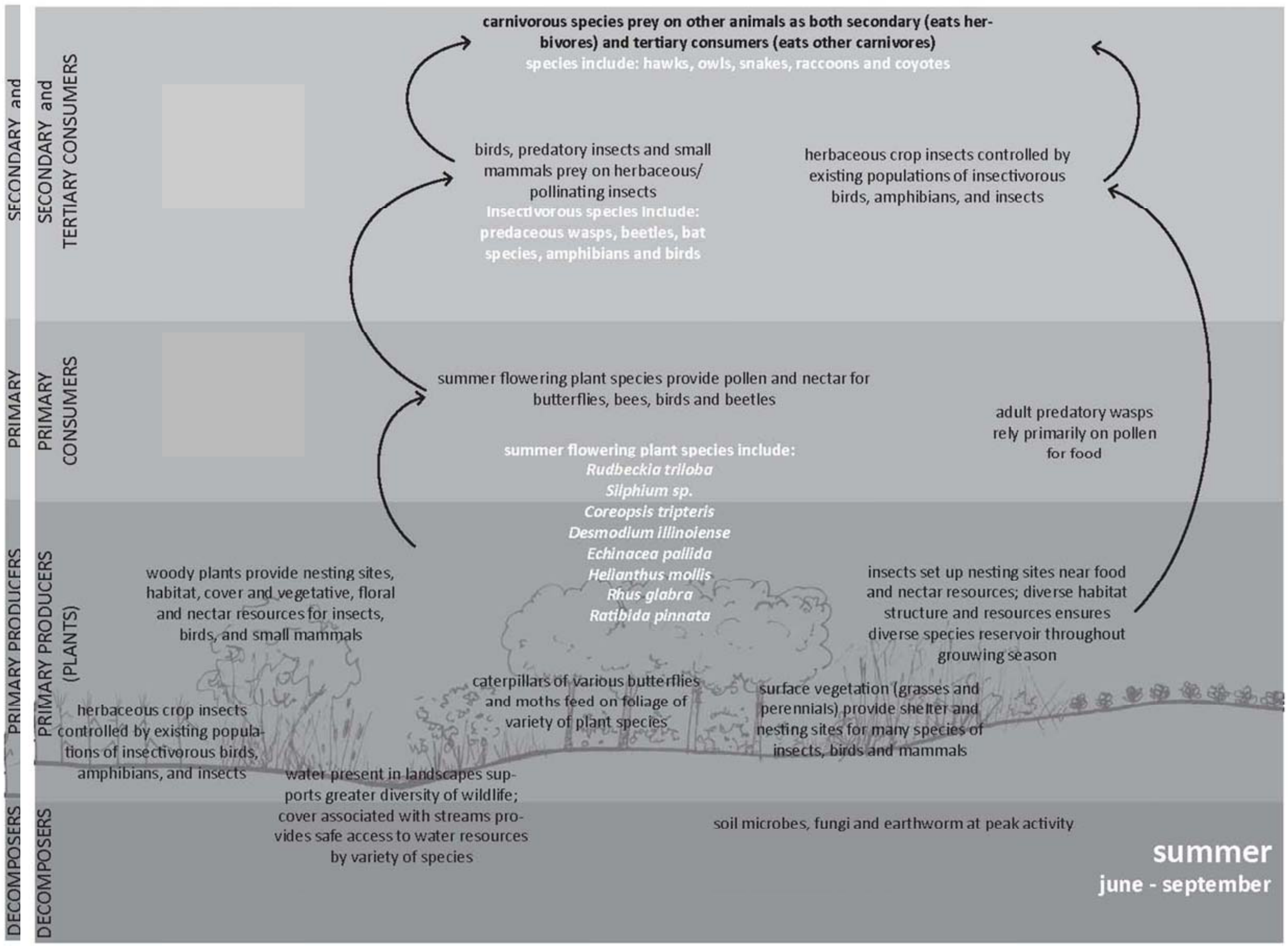

Figure 19. Spring Food Web Diagram. (Diagram by author.)

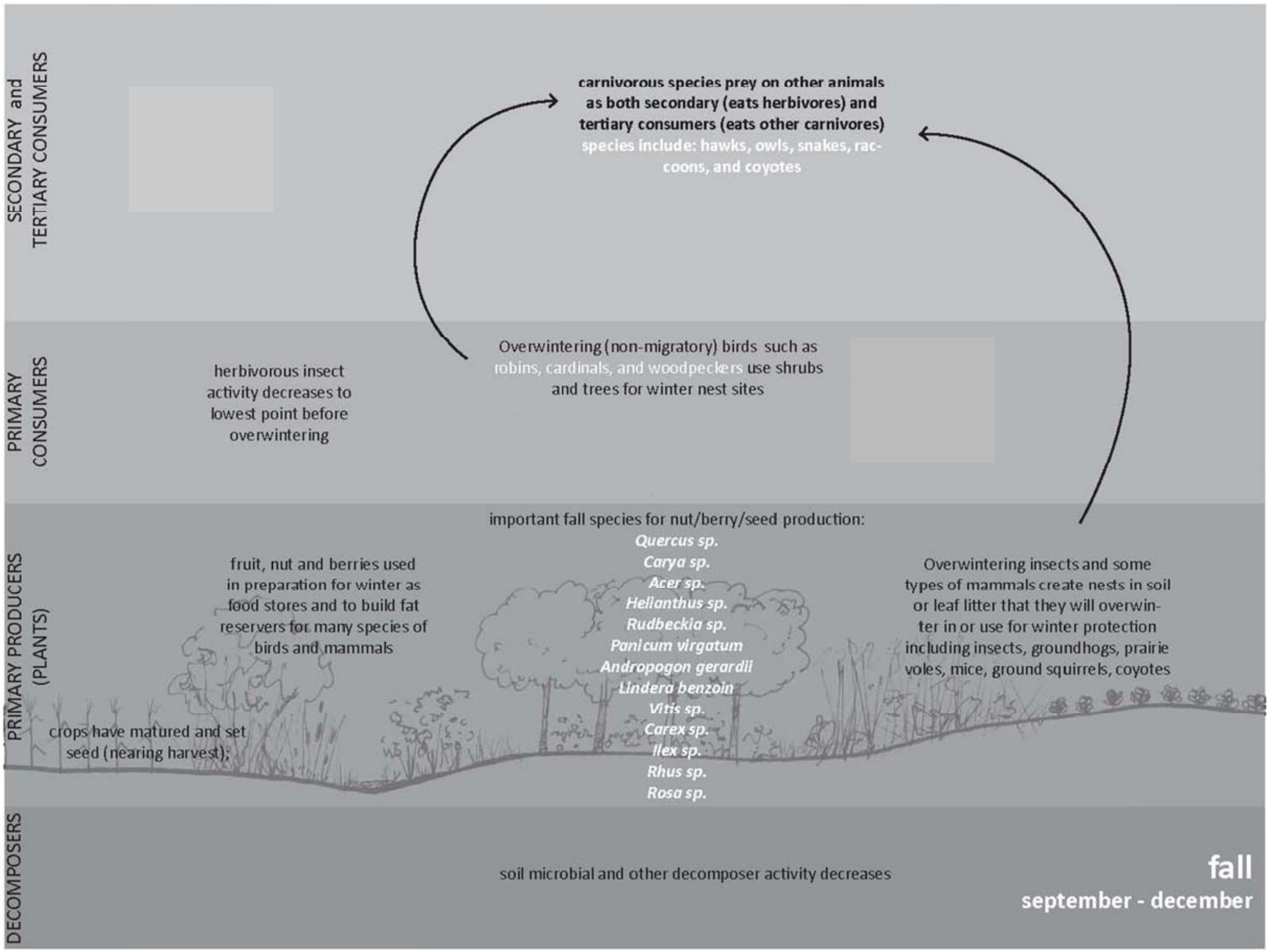

Figure 20. Fall Food Web Diagram. (Diagram by author.)

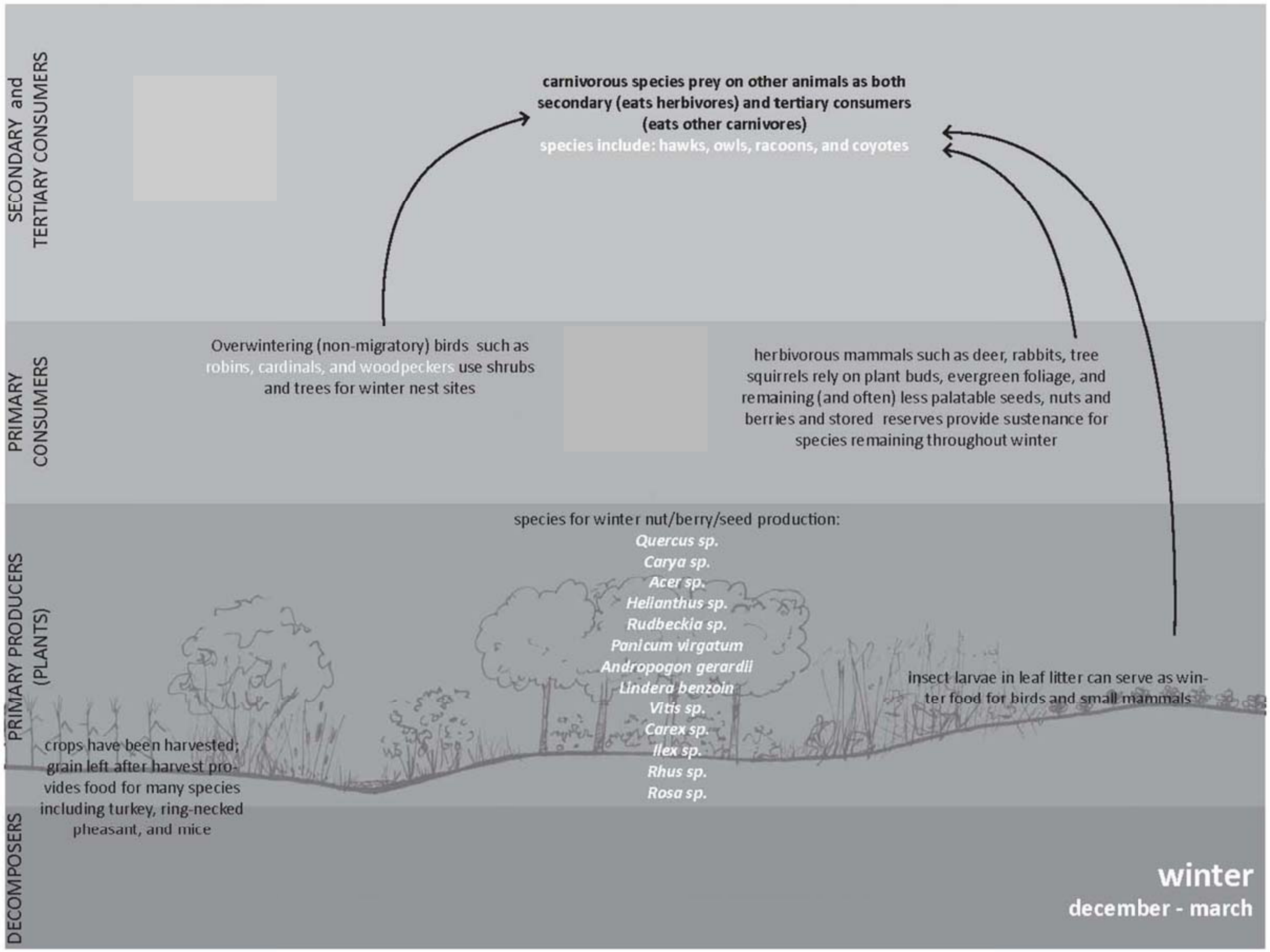

Figure 21. Winter Food Web Diagram. (Diagram by author.)

CHAPTER 6: CONCLUSION

This thesis represents an exploration of the topic of agriculture and the role of the landscape designers and planners in the development of ideas and visions and in providing the inspiration to move the endeavor forward of creating a sustainable rural countryside.

Through the review of current research about sustainable agriculture, focused on the question of how, why and should biodiversity be a part of the vision for a sustainable agriculture, I hoped to illustrate that biodiversity is in fact a vital part of any future vision of sustainable agriculture. In the subsequent section of the paper, I illustrated through the exploration of research on landscape design and planning the potential role that landscape design can play in envisioning this sustainable future. Landscape design can bridge the gap between science and society helping, and through collaborative efforts with professionals and scientists can translate concepts into visions that can help convey complex ideas in order to generate dialogue so that a common future for all can be created. Lastly, using information from my own research on native species of Central Illinois, I developed a series of vignettes incorporating native plant species and correlated this vignettes to a seasonal food web diagram that illustrated ecosystem complexity and the importance of plant diversity in time and space.

Re-establishing biodiversity in areas where none or very little currently exists seems a complicated and difficult task. The question of who will be spearheading the movement is difficult enough, much less the question of how. Ecologist Shahid Naeem, et al. proposed a "thought experiment" in a recent article in which the earth was sterilized and it was under the complete control of humans to restore biodiversity to support our own survival and well-being. Suffice it to say the factors that must be considered in order to construct such an environment was overwhelming –precisely to illustrate the impossibility of just such a task and also to show that "every species contributes to ecosystem function and human wellbeing in complex ways, though obviously at different levels (from negligible to enormous) and with different impacts on humans (from beneficial to harmful)" (2009, 6). This experiment seems little different than rebuilding biodiversity in Central Illinois where so much native biodiversity has already been destroyed. It seems that the monoculture approach was one attempt at recolonizing a sterilized environment, but we're learning it's at far too great a cost to our own as well as the planet's health and wellbeing. Re-introducing biodiversity may not be neat or tidy and we can likely not (and should not try to) fully control ecosystem processes.

This ecosystem complexity became startlingly apparent through the development of the landscape vignettes and seasonal food web. Initially I had intended to create a planting chart similar to those often used in landscape design firms to quickly illustrate proposed species, height and size, flower color and seasonal interest to a client. But this chart became enormously complex with the multitude of factors that must be considered in biodiversity restoration. It is understandable as such why biodiversity restoration is often focused on a key species of an ecosystem assuming that if the key species is provided for than all other species will be as well (give or take a few). But in general biodiversity restoration where there may be no particular species of concern (or all species are of concern) then structuring a planting scheme becomes extremely complex. But, as suggested in the aforementioned article (Naeem et al 2009), it may just call for a strategy where we restore, monitor, and then adjust where necessary.

The importance of native species cannot I believe, be overstated. As discussed in Chapter 2, if biodiversity is to be preserved native species must be valued over the importation of foreign. Given the large number of native species (Illinois has about 3000) and that native ecosystems were able to provide for themselves prior to European settlement it seems logical to conclude that native species exist that can provide desired local ecosystem services. As to which ones and potential "ideal" combinations of these species in agricultural systems is a necessary area of research. In this paper I didn't use the cultural or aesthetic argument for native species preservation for it is a much more difficult argument to make, and there is little possibility of general consensus or agreement on this topic. Thus I sought to make the argument based on the logic that if biodiversity is important then we must conclude that native species are important as well. But from a landscape design point of view native species have a great deal of cultural and aesthetic value in that they are the part and parcel of the place, and confer the ever important "sense of place" to a landscape. To value any particular place or landscape one must also value the plants and animals that are native to that place.

The Millennium Ecosystem Assessment states that biodiversity is essential as it is the foundation for the provisioning of ecosystem services that have a direct impact on *human well-being,* which in the scope of the Assessment includes people's income and material needs, freedom of choice and action, health and good social relations (Millennium Ecosystem Assessment 2005). While this paper has focused on the environmental and ecological aspects of sustainable agriculture, much more could be said in regard to the positive social, economic, and potential health benefits of improving agricultural sustainability through integration with biodiversity and would indeed be a valuable area of research and exploration. This thesis project attempted to illustrate the importance of native species and biodiversity to the sustainability of agricultural regions in Central Illinois.

The concepts and ideas proposed in this thesis are largely untested in Central Illinois, and most of the Midwest. I am personally unaware of large-scale biodiversity restoration projects that essentially started from scratch and that were highly integrated within a productive agricultural matrix. I feel though that current research regarding the importance of biodiversity for the provision of ecosystem services, conservation of natural resources and continued productivity and sustainability of agricultural production indicates that such a proposal is not only possible but necessary for continued human health and wellbeing at present time and for many generations to come.

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